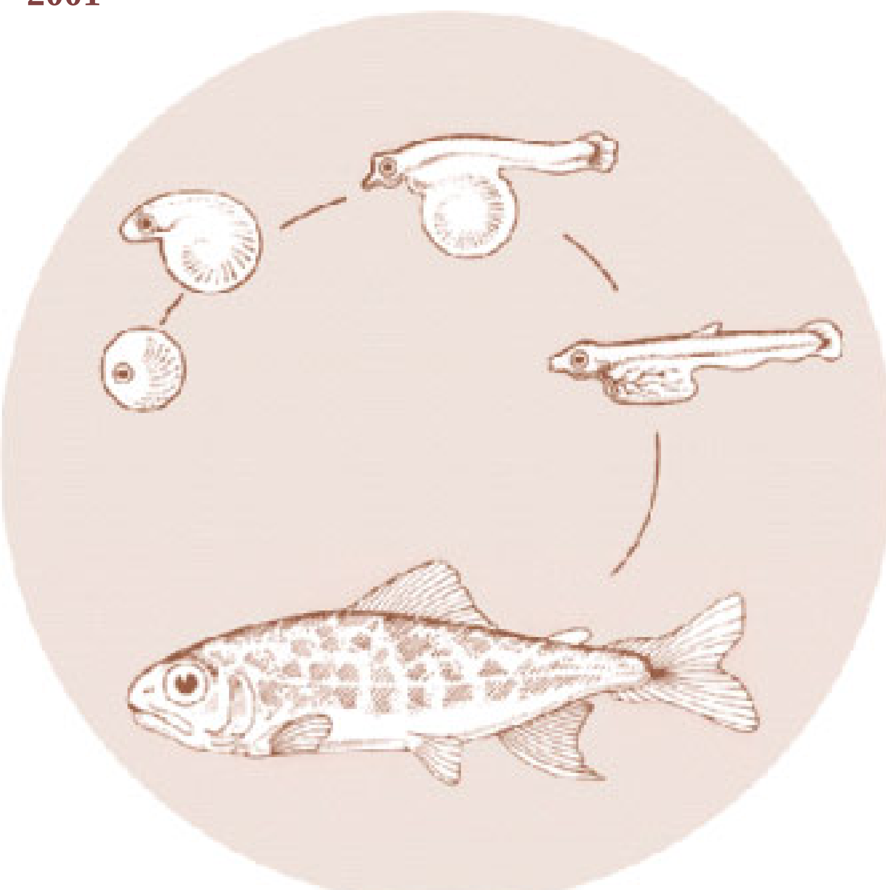
Kelt Reconditioning: A Research Project to Enhance Iteroparity in Columbia Basin Steelhead (Oncorhynchus mykiss)

Annual Report
2001



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2001 Annual Report

Kelt Reconditioning: A Research Project to Enhance Iteroparity in Columbia Basin Steelhead *(Oncorhynchus mykiss)*

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ABSTRACT

Repeat spawning is a life history strategy that is expressed by some species from the family Salmonidae. Rates of repeat spawning for post-development Columbia River steelhead (*Oncorhynchus mykiss*) populations range from 1.6 to 17%. It is expected that currently observed iteroparity rates for wild steelhead in the Basin are artificially and in some cases severely depressed due to development and operation of the hydropower system and various additional anthropogenic factors. Increasing the natural expression of historical repeat spawning rates using fish culturing means could be a viable technique to assist the recovery of depressed steelhead populations. Reconditioning is the process of culturing post-spawned fish (kelts) in a captive environment until they are able to reinitiate feeding, growth, and again develop mature gonads. Kelt reconditioning techniques were initially developed for Atlantic salmon (*Salmo salar)* and sea-trout *(S. trutta).* The recent Endangered Species Act listing of many Columbia Basin steelhead populations has prompted interest in developing reconditioning methods for wild steelhead populations within the Basin. To address recovery, we captured wild emigrating steelhead kelts from the Yakima River and tested reconditioning and the effects of several diet formulations on its success at Prosser Hatchery on the Yakama Reservation.

Steelhead kelts from the Yakima River were collected at the Chandler Juvenile Evaluation Facility (CJEF, located at Yakima River kilometer 48) from 12 March to 5 July 2001. Kelts were reconditioned in circular tanks and fed a mixed diet of starter paste, adult sized trout pellets, and freeze-dried krill. Formalin was used to control outbreaks of fungus and we tested the use of Ivermectin™ to control internal parasites (e.g., *Salmincola spp.*). Surviving specimens were released for natural spawning in two groups on 15 November 2001 and 18 January 2002. Overall success of the reconditioning process was based on the proportion of fish that survived in captivity, gained weight, and the number of fish that successfully underwent gonadal recrudescence. Many of the reconditioned kelts were radio tagged to assess their spawning migration behavior and success following release from Prosser Hatchery. In total, 551 kelts were collected for reconditioning at Prosser Hatchery. Captive specimens represented 18.7% (551 of 2,942) of the entire 2000-2001Yakima River wild steelhead population, based on fish ladder counts at Prosser Dam. At the conclusion of the experiments (208-323 days from capture), 108 fish (19.6%) had survived and were released to spawn in the wild. Ultrasound examination – to determine sex and reproductive development– determined that 100 (94.3%) of 106 sex-identified specimens were female and we estimated that 96% of the reconditioned releases gained weight and developed mature gonads. Nearly one quarter (24.3%) of all reconditioned kelts survived for the duration of the experiment.

As in previous years, the kelts reconditioned during this project will substantially bolster the number of repeat spawners in the Yakima River. Valuable knowledge regarding Kelt husbandry, food type preferences, condition, and rearing environments were obtained during this research endeavor. Although higher survival rates would have been desirable, the authors were encouraged by the positive results of this innovative project. Nearly 20% of the kelts collected were successfully reconditioned, and radio telemetry allowed us to track some of these fish to the spawning grounds and to obtain documentation of successful redd construction. Information collected during this feasibility study has been significantly incorporated into the experimental

design for upcoming years of research, and is expected to continue to increase survival and successful expression of iteroparity.

ACKNOWLEDGEMENTS

The Bonneville Power Administration, under the direction of the Northwest Power Planning Council funded this project. We sincerely appreciate the support, scientific review, and ongoing communication between our project staff and these groups. We sincerely appreciate the assistance of Roy Beaty, the project's Contracting Officer Technical Representative, for his help with the 2001 research endeavor. The U.S. Bureau of Reclamation owns the land and the fish facilities, and provided services to Prosser Dam and Prosser Hatchery, and we appreciate their support.

We also thank Michael (Sonny) Fiander, Carrie Skahan, Chuck Carl, Mark Johnston, Jim Dunnigan, Todd Newsome and other Yakama Nation Fisheries Program staff for providing fish husbandry and telemetry expertise. This work would not have been possible without their assistance. We thank André Talbot, Phil Roger, and John Whiteaker from the Columbia River Inter-Tribal Fish Commission for their comments on the project and reviews of the annual report. Lastly, we thank the University of Idaho and the National Marine Fisheries Service for coordination and for donating radio tags to this project.

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INTRODUCTION

Populations of wild steelhead *(Oncorhynchus mykiss)* have declined dramatically from historical levels in the Columbia and Snake rivers (Nehlsen et al. 1991; NRC 1996; *US v. Oregon* 1997; ISRP 1999). Steelhead in the upper Columbia River have been listed as endangered under the Endangered Species Act (ESA) since 1997[1]. Those in the Snake River have been listed as threatened, also since 1997[1], and those in the mid-Columbia were listed as threatened in 1999[2]. Causes of the declines are numerous and well known (TRP 1995; NPPC 1986; NRC 1996; ISRP 1999), and regional plans recognize the need to protect and enhance weak upriver steelhead populations while maintaining the genetic integrity of those stocks (NPPC 1995).

Iteroparity rates for *0. mykiss* were estimated to be as high as 79% for 1994-96 in the Utkholok River of Kamchatka (MSU undated; M. Powell UI and R. Williams, ISRP personal communication) Reported iteroparity rates for Columbia basin steelhead were considerably lower, due largely to high mortality of downstream migrating Kelts at hydropower dams (Evans and Beaty 2001; Evans In Review), and to inherent differences in iteroparity rate based on geography (e.g. latitudinal effect, inland distance effect; Withler 1966; Bell 1980; Fleming 1998). Outmigrating steelhead averaged 58% of annual upstream runs in the Clackamas river from 1956 to 1964 (Gunsolus and Eicher 1970). Recent estimates of repeat spawners in the Kalama River (tributary of the unimpounded lower Columbia River) have exceeded 17% (NMFS 1996), which is the highest published iteroparity rate we found from the Columbia River Basin. Farther upstream, 4.6% of the summer run in the Hood River (above only one mainstem dam) are repeat spawners (J. Newton, ODFW, pers. comm.). Iteroparity for Klickitat River steelhead was reported at 3.3% from 1979 to 1981 (Howell et al. 1984). Summer steelhead in the South Fork Walla Walla River exhibited estimated 2% to 9% iteroparity rates (J. Gourmand, ODFW, pers. comm.), whereas repeat spawners composed only 1.6% of the Yakima River wild run (from data in Hockersmith et al. 1995) and 1.5% of the Columbia River run upstream from Priest Rapids Dam (L. Brown, WDFW, unpubl. data).

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[1] Final Rule 8/18/97: 62 FR 43937-43954.
[2] Final Rule 3/25/99: 64 FR 14517-14528.

Before repeat spawners can contribute to population growth and diversity, they must first successfully emigrate to the ocean following spawning. The term "kelt" has been used to describe this unique post-spawned life history phase within salmonids. In 1999 and 2000 ultrasound and visual methods were developed – with funding from the U.S. Army Corp of Engineers – to accurately distinguish kelts from pre-spawners (mature steelhead). The ultrasound technique provided a highly accurate and non-invasive way to enumerate the abundance of kelts in the Snake and Columbia rivers basins (Evans and Beaty 2000). Using this technique, Kelts were enumerated at Little Goose bypass (1999 and 2000), Lower Granite bypass (2000 and 2001), and at McNary and John Day bypass facilities (2001). Data revealed that approximately 2,780 wild kelts, equivalent to *ca.* 23% of the 1999 wild run above Lower Granite Dam, passed through the juvenile collections systems at Lower Granite and Little Goose dams in the spring of 2000 (Evans and Beaty 2001). In 2001, an estimated 4,695 wild kelts, equivalent to *ca*. 21% of the 2000 wild run, passed through Lower Granite bypass facility alone. The majority of kelts were considered to be in good physical condition (> 70%) and the kelt run was predominately female (> 80%). A trend toward higher post-spawn female survival, relative to males, is consistent with data from other iteroparous populations (Withler 1966, Leider et al. 1986, Jonsson et al. 1991, Fleming 1998, and Niemela et al. 2000).

Despite the thousands of kelts that arrived at Lower Granite Dam during 2001, very few successfully navigated the Columbia Basin hydrosystem. Radio telemetry indicated that only 24.1% (51/212) and 3.8% (8/212) of tagged kelts released from Lower Granite Dam tailrace reached the Ice Harbor Dam tailrace and Bonneville Dam tailrace, respectively. In addition to kelt mortality associated with dam passage, depleted energy stores and physical deterioration likely constituted important mortality, compounded by fasting for many months during migration and spawning (Love 1970). However, based on the above suite of empirical iteroparity estimates, steelhead kelts in impounded areas of the Columbia Basin should have significantly greater likelihood of exhibiting iteroparity if they are reconditioned in captivity, relative to their current inability to exhibit iteroparity in the impounded, post-development Columbia River Basin.

Kelt reconditioning promotes re-initiation of feeding, thereby enabling them to survive and rebuild energy reserves required for proper gonadal development and iteroparous spawning. Kelt reconditioning techniques were initially developed for Atlantic salmon (*Salmo salar)* and sea-trout *S. trutta.* A review of these studies and those applicable to steelhead kelts are summarized in Evans et al. (2001). Along with additional reviews of this subject (Evans 2000, Evans et al. 2001) provided strong support beneficial use of kelt reconditioning to address population demographic and genetic issues of steelhead recovery in the Columbia River Basin. This project identifies and systematically tests several kelt reconditioning approaches.

In order to experimentally evaluate the feasibility of kelt reconditioning as a potential recovery and restoration strategy for wild steelhead in the Columbia River basin, this project is designed to satisfy the following research objectives:

Objective 1: Collect and recondition wild Yakima River steelhead kelts at Chandler Dam/Prosser Hatchery.

Objective 2: Produce and evaluate specialized diets to maximize the success of steelhead kelt reconditioning.

Objective 3: Evaluate the management implications of kelt reconditioning

Objective 4: Provide planning, coordination, and information exchange for the kelt reconditioning program.

Finally, this kelt reconditioning research exists in a broader research context, in which it is one of three experimental treatments to assess methods of increasing natural expression of iteroparity by wild Columbia River basin steelhead. In addition to steelhead kelt reconditioning research presented in this report, the other two treatments evaluating enhanced iteroparity expression are: 1) In-river kelt emigration; and 2) Transporting emigrating kelts in barges from Lower Granite Dam on the Snake River to downstream from Bonneville Dam on the lower Columbia River (i.e. bypassing kelts around the hydro system). These two treatments represent additional CRITFC kelt research, funded by the U.S. Army Corps of Engineers, which strongly complements the kelt reconditioning research presented in the annual report. Pairwise comparisons of the success, efficiency, and cost-effectiveness of these three experimental treatments will be made after rigorously tested and replicated under the BPA Mainstem/Systemwide Province research opportunity (2003-2005).

METHODS

Area and Facilities - Kelt reconditioning research was conducted at the Prosser Fish Hatchery in Prosser, Washington. Prosser Hatchery is located on the Yakima River (river kilometer, (rkm) 48), downstream from Prosser Dam, and adjacent to the Chandler Juvenile Evaluation Facility (CJEF). The Yakima River Basin is approximately 344 km in length and enters the Columbia River at rkm 539. Summer steelhead populations primarily spawn upstream from Prosser Dam in Satus Creek, Toppenish Creek, Naches River, and other subbasins of the Yakima River (TRP 1995). The Yakama Nation (YN) operates Prosser Hatchery, and the hatchery's primary function is for rearing, acclimation and release of juvenile fall chinook salmon (*O. tshawytscha*). The facility is also used for coho salmon (*O. kisutch*) rearing prior to their acclimation in the upper Yakima River Basin.

Kelt Collection and In-Processing - After naturally spawning in tributaries of the Yakima River, a proportion of the steelhead kelts that encounter Prosser Dam facility during emigration are diverted into an irrigation channel that directly connects to the Chandler Juvenile Evaluation Facility. Like other bypass facilities in the Columbia Basin, the CJEF diverts migratory fishes away from the dam to reduce mortality. The CJEF was used to capture kelts, in which we manually graded emigrating kelts that arrived on the separator (a fish separation device initially designed to capture juvenile salmonids). Yakama Nation (YN) staff monitored the Chandler bypass separator 24 hours a day from 12 March to 5 July 2001. All adult steelhead arriving at the CJEF separator, regardless of maturation status (kelt or pre-spawn[3]), were dipnetted off the separator and placed into a water-lubricated PVC pipe slide that was directly connected to a temporary holding tank 20' (l) x 6' (w) x 4'(h) containing oxygenated well water.

Emigrating steelhead kelt specimens were transferred with a dipnet from the temporary holding tank to a nearby 190-L sampling tank containing fresh river water, where they were anesthetized in a buffered solution of tricaine methanesulfonate (MS-222) at 60 ppm. All specimens determined to be kelts (based on visual examination) were collected for reconditioning. Following kelt identification, we collected data on fish length (cm fork length), weight (collected in pounds but converted to kg for this report), condition (good, fair, poor), coloration (bright, intermediate, dark), and presence or absence of physical anomalies (e.g., head burn, eye damage). Passive Integrated Transponder (PIT) tags were then implanted in the fish's pelvic girdle for individual fish identification during reconditioning.

Reconditioning Tanks - Upon admission of kelts to the reconditioning program at Prosser Hatchery, all were held and reconditioned on-site in one of four 20'(l) x 20'(w) x 4'(h) circular tanks. This modification from past years' reconditioning research occurred in response to undesirable mortality associated with fish damage occurring during past years in rectangular tanks. Individual tank carrying capacity was set at 200 fish based on the aquaculture experience of YN hatchery staff, and the project goal of maximizing kelt survival in captivity. Formalin was administered five times weekly at 1:6,000 for 1 hour in all reconditioning tanks to minimize fungal outbreaks.

Feeding and Treatment - Previously frozen whole krill were fed to all kelts retained for reconditioning research at Prosser Hatchery during 2001, based on the empirical success of this diet to re-initiate feeding during the previous year (Evans et al. 2000). To address potential effects of various diet formulations and feed presentations on the success of steelhead kelt reconditioning, maintenance and growth (M/G) feeding trials were performed during 2001 in the four 20' dia. circular reconditioning tanks at the Prosser Hatchery. One of four different experimental diets (Floating pellet, Abernathy, Moore-Clarke Kelt, and krill) was fed to reconditioning steelhead kelts in each of the four tanks, and fish performance measures (survival, length and weight gain) were recorded. Fish nutritionist Dr. Anne Gannam at the U.S. Fish and Wildlife service's Abernathy Fish Technology Center, in Longview, Washington performed detailed proximate analysis of the three pelleted feeds. Results of this analysis were presented in a separate report (Appendix A).

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[3] The term pre-spawner refers to a sexually mature fish.

The following design, employing four tanks was used in the feeding treatment tests:

C1 = Fish were collected from 12 March to 20 April, 2001 and received krill followed by Moore Clark adult salmon pellets.

C2 = Fish were collected from 22 March to 27 April, 2001 and received the "special diet" only.

C3 = Fish were collected and randomly allocated to tank from 23 April to 5 June, 2001 and received krill followed by Moore Clark adult salmon pellets.

C4 = Fish were collected and randomly allocated to tank from 23 April to 5 June, 2001 and received only krill.

Notes: Fish from tank C2 were culled in July to remove non-feeders Also, fish from C1 and C2 were temporarily held (1-2 weeks) in smaller tanks until they could be transferred to the large circulars. Kelts in C3 and C4 were randomly allocated and left alone (i.e., not periodically moved or sample) throughout the study period. It is also important to note that kelts from C3 and C4 were collected after tanks C1 and C2 were filled. Thus, collection date may be an important yet compounding issue if you want to compare all four tanks.

Tank	C1	C2	C3	C4
No. Collected	130	132	105	102
No. (%) Surviving	58 (45%)	28 (21%)	54 (51%)	40 (39%)
No. (%) Mature	37 (28%)	19 (14%)	26 (25%)	10 (10%)
In-Weight (x)	4.69	4.44	4.37	4.36
Out-Weight (x)	6.91	5.51	7.11	5.07

Note: Only fish that retained their PIT tags (n=180) and/or had complete histories are included in this table. Thus, I had to assume fish that lost their PIT tags (n=17) did so equally among each tank.

In closed aquatic environments, such as kelt reconditioning tanks, severe infestation of parasites can be lethal to cultured fishes, which may be especially susceptible to Salmincola in such environments. Salmincola is a genus of parasitic copepods that can inhibit oxygen uptake and gas exchange at the gill lamellae/water surface interface by attachment to the lamellae. Recent research by Johnson and Heindel (2000), suggested that Ivermectin™ – a treatment often used to control parasites in swine and cattle – can increase the survivorship of cultured fish by killing the adult morph of the parasite. Due to its successful use in treating Salmonicola in this project's kelt reconditioning experiments during 2000 (Evans et al. 2000), Ivermectin™ was again diluted with saline (1:30) and injected into the posterior end of the fish's esophagus using a small (10cc) plastic syringe. As in previous years, success of Ivermectin™ treatment was assessed based on the prevalence of parasites in test fish relative to non-treated fish at release.

Kelt mortality - The following data were collected on all kelts that died during the reconditioning process at Prosser Hatchery. On discovery of a mortality, fish were first subjected to an external examination by hatchery personnel to record the suspected time of death, general condition (good, fair, poor), fish color (bright, intermediate, dark), color of the gill arches (red, pink, white), size of the abdomen (fat, thin), presence of any scars or obvious lesions, and any other anomalies. Once the external exam was completed, an internal examination was conducted to record color of muscle tissue (red, pink, white), type of gonads (ovaries, testes), size of gametes (small, large), and presence of any internal anomalies. PIT tags were also recaptured from mortalities and identification numbers were entered into a computer database along with the morphometric data.

Maturation Assessment and Release for Spawning - On November 15, 2001 and again on January 18, 2002 all surviving steelhead were examined with ultrasound equipment to assess maturation status, and those that had developed new gonads were released for natural spawning (1 male was released separately on January 29, 2002). We selected this time because it coincided with the natural return of many Yakima River steelhead. Morphometric data regarding fork length, weight, and presence/absence of parasites – to assess the Ivermectin™ treatments – were also recorded on all released individuals. Overall success of the reconditioning process was based on the proportion of fish that survived captivity, gained weight, and the number of fish that successfully underwent gonadal recrudescence (based on ultrasound examinations).

Radio Telemetry: Of the 108 steelhead released for spawning, 61 were radio-tagged prior to release. The radio tags were manufactured by Advanced Technology Systems (ATS) and were powered by a 3.6 volt Hawker Eternacell battery. Each tag had unique bandwidth pulses that provided individual identification codes. Each tag was programmed to last 6 months and was inserted using the gastric insertion technique. All radio-tagged kelts were released at Mabton/ Sunnyside Bridge (Rkm 96.2), and were tracked using a variety of methods including, mobile tracking, fixed sites and aerial surveys. The fixed sites were located at Prosser Dam (Rkm 75.8), Slagg Ranch (Rkm 106.2), Sunnyside Dam (Rkm 167.0), Roza Dam (Rkm 205.8), Naches River (Cowiche Dam Rkm 5.8), Toppenish Creek (Rkm 71.1) and Simcoe Creek (Rkm 13.0). There were a total of 9 flights done from March through May 2002. These flights proved to be essential in locating fish and investigating the disappearance of kelts. Flights were done in all the basins and were prioritized by fish movement. Mobile tracking was done by road and by raft. Mobile tracking allowed for actual pinpoint location and the eventual observation of kelts that were building redds and spawning. The mobile and fixed radio-tracking receivers were made by Lotek Inc. and National Marine Fisheries Service (NMFS). We relied primarily upon upstream movement and visual observations as indicators of live fish. Tags were recovered from dead fish whenever possible.

Program Evaluation, Implementation, and Coordination - An additional objective of this research was to evaluate potential management implications of kelt reconditioning. This objective was performed in conjunction with the development of a project-specific scoping document and additional requested evaluations consistent with requirements of the NWPPC's 3-Step Review Process for hatchery facilities and programs. Results and brief discussions of these evaluations are presented in this report. However, we recommend that readers consult Appendices B (Kelt Reconditioning Project Scoping Document) and C (Kelt Reconditioning Project Partial 3-Step review Process Document) for more empirical and theoretical detail regarding management implications of steelhead kelt reconditioning.

The final research objective of this project involved the planning, coordination, and information exchange. This report provides a discussion of the products, mechanisms, and entities involved in successful information exchange, planning, review, and coordination.

RESULTS/DISCUSSION

Kelt Collection and In-Processing Statistics - A total of 551 kelts were collected for reconditioning at Prosser Hatchery from 12 March to 5 July 2001. Collection generally followed a normal distribution with the peak collection day occurring around May 7 (Figure 1). Overall, kelts captured for reconditioning represented 18.7% (551 of 2,942) of the entire Yakima River ESA-listed population, based on fish ladder counts obtained from Prosser Dam for the period July 1, 2000 to June 30, 2001. It is possible that many of the emigrating kelts from the Yakima River were never diverted into the irrigation channel preventing their collection for reconditioning, and may have passed instead over the dam's spillway. Thus, a large proportion (probably in excess of 20%) of the adult steelhead that successfully reached Prosser Dam during the fall of 2000 and winter of 2001 survived their initial spawning and attempted emigration as kelts during the spring of 2001.

In contrast to the abundance of kelts in the CJEF, pre-spawn steelhead were encountered less frequently during capture and in-processing. Approximately 177 wild pre-spawn migrants were culled off the Chandler bypass separator from 12 March to 5 July, 2001 and released directly into the river. Of the steelhead sampled during this same time period, 14 were determined to be of hatchery origin, based on external mark and/or internal CWT/PIT tag detection.

Many of the emigrating kelts appeared emaciated upon capture at Chandler bypass. Abdominal surfaces, recorded as thin during in-processing, were often so gaunt that the specimens had a "snake-like" appearance. The average weight of captured kelts was 2.04 kg (range: 0.82 - 3.72 kg). Research on energy expenditure during migration and spawning, a period when many salmonids are believed to stop feeding, suggested that anadromous fish depleted over 60% of their lipid, protein, and ash reserves during the spawning process (Love 1970). Much of the muscle tissue during this time was converted into water and the digestive tract and stomach lining can become severely arthritic. The overwhelming majority of kelts captured as part of this reconditioning research project were female (Table 1). Based on visual observations, 487 (88.4%) of the kelts were classified as female, whereas only 16 (2.9%) as male.

Table 1: Sex and survival to release of adult steelhead captured for reconditioning at Prosser Hatchery, 2001-02.

Sex	No. Captured	No. Released
Male	16 (3%)	6
Female	487 (88%)	100
Unknown/Unidentified	48 (9%)	2
Total	551	108

The gender of 48 steelhead (8.7%) was unknown at the time of collection due to difficulties associated with gender identification techniques. The majority of kelts collected during 2001 were considered in good or fair overall condition. In terms of gross morphological and physiological condition, 218 (39.6%) kelts were classified as good, 328 (59.5%) as fair and 5 (0.9%) as being in poor condition. Regarding fish coloration, we classified 166 (30.1%) as bright, 354 (64.2%) as intermediate, and 31 (5.6%) as dark.

During both 2000 (n=452) and 2001 (n=487) approximately 88% of all collected kelts were female. However, during 2001, gender of an additional 8.7 % of kelts (n=48) was undetermined. Unlike sex ration data between years, kelt condition differed between years. During 2000 the "good-fair-poor" condition ratio, expressed as a percent of total kelts collected was 85-10-5 (Evans et al 2000). The same ratio from 2001 kelts (n=487) was approximately 40-59-1. Inter-annual differences in kelt coloration data were somewhat consistent with these inter-annual differences in condition. During 2000, the "bright-intermediate-dark" coloration ratio, expressed as a percentage of kelts collected, as 64-29-7, compared with 30-64-6 from 2001 kelts. Thus, a higher percentage of kelts recorded as bright during 2000 was accompanied by a high by an increased percentage of fish in good condition. These annual differences could have been due to chance, differences in timing, freshwater and marine ecological conditions, and observation and category classification changes between years.

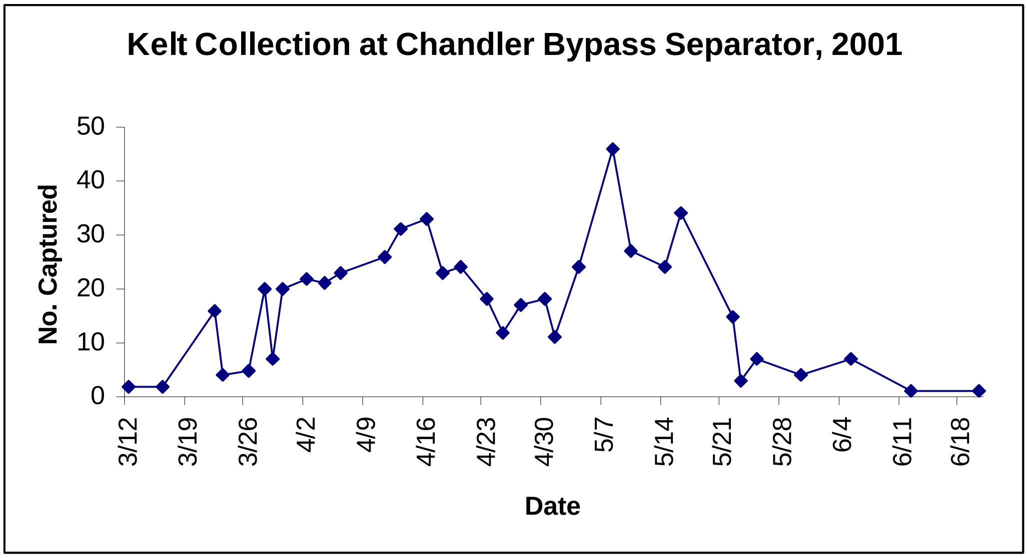

Figure 1. Kelt collection dates and numbers of fish removed from Chandler bypass facility involved in reconditioning procedures at Prosser Hatchery during 2001.

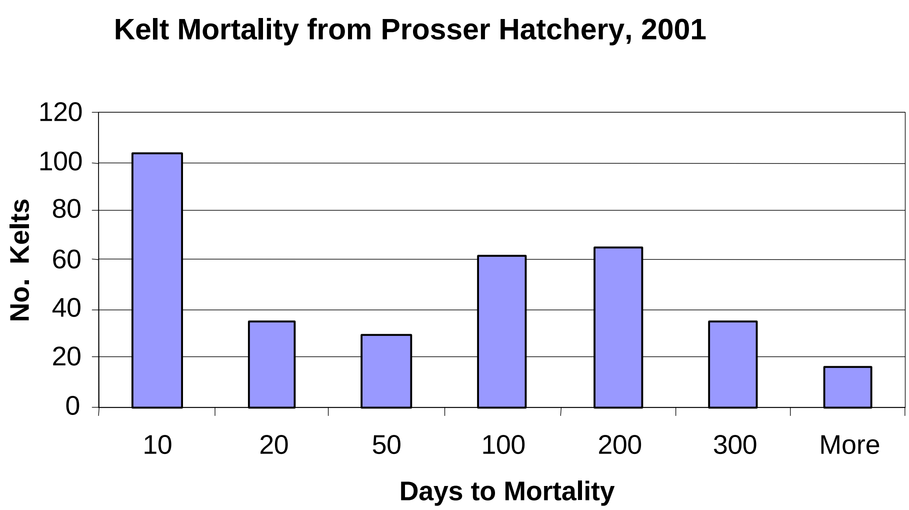

Figure 2. The number of days from capture-to-death of Kelts collected for reconditioning at Prosser Hatchery during 2001.

Kelt Survival, Maturation, and Growth - On November 15, 2001 and again on January 18, 2002 all surviving steelhead were examined with ultrasound equipment to assess maturation status and released for natural spawning (1 male was released separately on January 29, 2002). In total, 134 (24.3% of the total collected) adult steelhead were alive at the conclusion of the experiment.

Of those fish alive at the conclusion of the experiment, ultrasound examination determined that 108 individuals (86%) had developed a full complement of eggs or sperm and were released to the river to spawn, and 26 fish (91%) were classified as being immature and were returned to the reconditioning ponds. No kelts were released prior to ultrasound examination. Of 95 reconditioned and released fish with known collection and release weights, two fish lost weight, two had no gain or loss, and the remaining 91 of 95 fish (95.8%) gained weight. A total of 27 of these fish (28.4%) more than doubled their weight during the reconditioning period. The mean weight change (increase) as a percentage of collection weight was 71.3% (Figure 3). In total, we determined that 108 of 551 fish (19.6%) were successfully reconditioned during the course of the study, based on both ultrasound examination and weight gain. Of those fish considered mature and released, 94.3% (100 fish) were female, and six were male (2 fish were released with no gender documentation).

Kelt Mortality Statistics - Of the 551 kelts collected for reconditioning during 2001, 417 (75.7%) died during the study period. The majority of kelt mortalities (66.5%) occurred within the first 100 days of captivity (calculated from the date of capture to the date of death for each individual specimen). The early death of captive kelts suggests that they never accepted or were unable to digest and absorb feed, and that their remaining energy reserves were insufficient to keep them alive beyond 100 days (Figure 2). Nearly one third of all kelts (30.1%, 104 of 346 fish) died within the first 10 days of capture. The authors suspect these individuals either died as a result of handling stress and/or were already in near-moribund condition upon collection. In contrast to the early mortality of many captive specimens, only 18.8% of fish died between 100 and 200 days (Figure 2). Of the 370 mortalities for which both collection and mortality weights were known, 129 (34.9%) either lost weight or had no gain, 141 (38.1%) gained 0.45 kg (1 lb.) or less, and 100 (27%) gained more than 0.45 kg (1 lb).

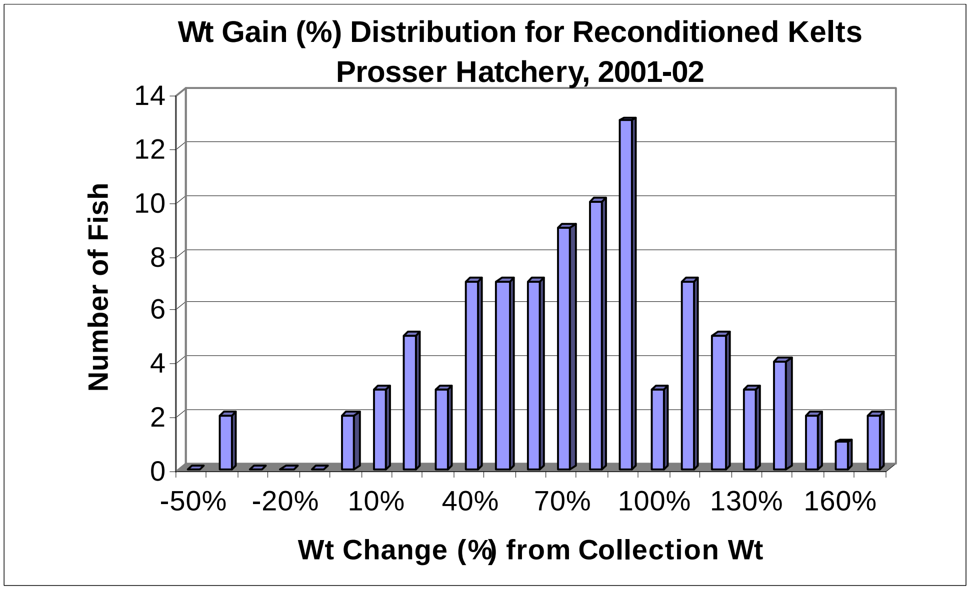

Figure 3: Weight gain distribution (weight gain as a percentage of collection weight) for kelts reconditioned and released at Prosser Hatchery during 2001-02.

The 2000 finding that more female than male kelts were collected at Chandler bypass was again observed during 2001, a finding supported by the literature (Withler 1966, Leider et al. 1986, Jonsson et al. 1991, Fleming 1998, and Niemel et al. 2000). However, male kelts survived nearly twice as well as females during 2001. While undergoing reconditioning during 2001, nearly one of every 3 kelts survived (6 of 16, 37.5%), compared with only about 1 of every 5 females (100 of 487, 20.5%) (Table 1). A study investigating steelhead populations along the Pacific Coast concluded that females composed 81.5% of all repeat spawners that were examined in eight different coastal rivers (Withler 1966). A review of iteroparous populations conducted by Fleming (1998) compared the sex ratios of repeat spawners within eight Salmoninae species (*Salmo salar, S. trutta, O. mykiss, Salvelinus malma, S. fontinalis, S. alpinus, S. namaycush, and S. huchen*). In all eight species repeat spawners were predominately female. In contrast, the ratio of male to females during the first reproductive episode was approximately equal within each species examined. In the natural environment, the lower ratio of post-spawned males to females may be a result of increased male-male competition on the spawning grounds (Fleming

1998, Niemel et al. 2000), resulting in higher male post-spawner mortality rates (Leider et al. 1986).

The consistent finding in this study that the large majority of all kelts available for reconditioning are female (approx. 88% during 2000 and 2001, Table 1) may be indicative of the evolutionary advantage of female iteroparity. Naturally occurring female iteroparity essentially acts in analogous ways as cryopreserving males in iteroparous salmon populations in the Columbia Basin. In addition, the fact that females are naturally able to reproduce with males during different years increases the probability of increased gene flow between and among cohorts or year classes. This has a direct theoretical benefit in the form of increasing the number of breeders (N_b), and the effective population size (N_e) during each spawning season, thus contributing to increased population viability and persistence, crucial to threatened and endangered fish restoration. Rather than a genetic hazard, experimental reconditioning should be viewed as a potential demographic and population genetic enhancement measure, aimed at restoring a recently jeopardized, but naturally occurring evolutionarily stable life history strategy.

In order for kelts to stop the post-spawning senescence process they must begin feeding and must gain weight. Nearly 96% of fish classified as mature at either the Nov. 15, 2001 or Jan. 18, 2002 examination gained weight during the reconditioning process while 75% (70/93) of the immature fish examined on these dates gained weight (Table 2, Figures 3 and 4). The mean weight change for immature (retained) kelts as a percentage of collection weight was 26.3% as compared to 71.3% for mature (released) fish (Figures 3 and 4).

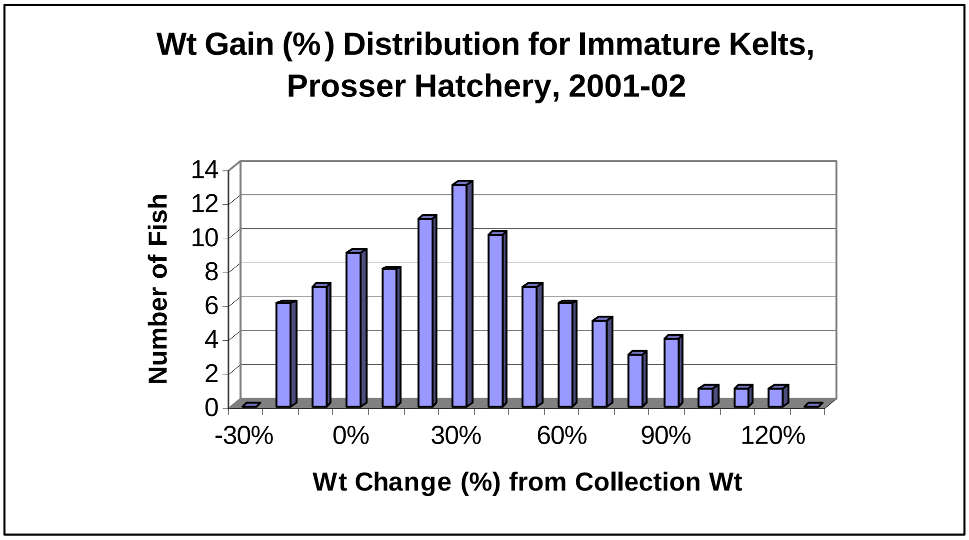

Figure 4: Weight gain distribution (weight gain as a percentage of collection weight) for immature kelts examined at Prosser Hatchery during 2001-02 recondition and release process.

The majority of mature fish (65%) increased in length, while the majority of the immature specimens (57.4%) actually showed a decrease in length (Table 2). Not surprisingly, many of those individuals that lost weight also lost length. Thus, it appears clear that kelts must gain substantial mass before they can reach maturity a second time, and that food intake may be the most critical aspect of reconditioning.

Table 2: Weight and (posteye to hypural) length statistics from adult steelhead examined at Prosser Hatchery, November 15, 2001 and January 18, 2002.

	Average weight increase (kg)	Average weight decrease (kg)	Average length increase (cm)	Average length decrease (cm)
Mature	1.43 (n=91)	- 0.66 (n=4)	4.71 (n=62)	- 1.67 (n=33)
Immature	0.69 (n=70)	- 0.27 (n=23)	3.65 (n=40)	- 1.63 (n=54)

Feeding and Treatment Summary - The experiment was completed on 11 November 2001 and 197 fish (39% of those collected) had survived in captivity at that time. Of these, ultrasound examination revealed that 109 fish had successfully re-matured (21% of the total collected and 55% of the surviving fish). A comparison of starter diets suggested that krill dramatically increased overall survival rates, as expected based on results from 2000. Kelts that received krill as a starter diet had an average survival rate of 45% compared to only 28% survival of kelts not exposed to krill. Despite the apparent advantages of krill, a maintenance feed was necessary to augment rematuration rates. In the absence of a maintenance diet, re-maturation rate was only 10% compared to a 27% rematuration rate with a maintenance diet. In general, results indicated that frozen krill followed by Moore-Clarke salmon pedigree diet provided the best overall survival and rematuration rates in 2001. Interestingly, 45% of the fish that survived in captivity during 2001 did not remature (88 of 197). However, half of these fish exhibited substantial somatic reconditioning, gaining > 0.5 kg in mass (44 of 88). If retained and fed at Prosser Hatchery for another year, we suspect many of these fish will remature during the subsequent fall.

There were no significant differences in the collection weight or length (data not shown) between captured specimens in all four tanks ($P > 0.20$, based on F-test). Krill appeared to be an important component to reconditioning, as evident from the higher survival rates in tanks C1, C3, and C4 relative to C2 (only tank that did not receive krill). Furthermore, the use of a maintenance diet is important for both overall survival and maturation rate, as evident from the fish in tanks C1, C2, C3 relative to C4 (only received krill). Although the culling of fish in C2 may have influence overall success, it appears that Moore Clark (tank C1 and C3) was the better maintenance diet compared to Ann’s feed (C2).

Spawning After Release - The ultimate success of kelt reconditioning should be assessed based on the number of individuals that successfully spawn in the wild following reconditioning and release. Although it is difficult to witness individual fish spawning in the wild, and even more difficult to assess the viability and quality of gametes, data are needed to determine if successfully reconditioned kelts contribute to subsequent generations.

Data collected by Foster and Schom (1989) provided evidence that the ability to home in Atlantic salmon kelts is imprinted during the fish’s juvenile life stage and that reconditioning does not alter homing instincts. Because the kelts collected at Prosser Dam are wild fish that could have originated in any of several upstream areas, we cannot know locations of specific spawning grounds for specific individuals. However, use of radio telemetry techniques can help address such critical uncertainties.

During the 2001-2002 season a total of 197 (35%) kelts survived reconditioning. Of the 197 surviving kelts, 108 re-matured and were released. The remaining 88 kelts were held longer, but the vast majority never matured. Sixty-one of the 108 were radio tagged and released. Each tag was inserted using the gastric insert technique. The first release of 55 radio tagged kelts occurred on November 15, 2001. The second release of 5 radio tagged kelts was on January 18, 2002. One additional kelt was radio tagged and released on January 29, 2002. All fish were released at Mabton (Rkm 96).

Of the 61 radio tagged kelts reconditioned and returned to the Yakima River during the 2001-02 study, 28 (46%) were detected in 9 tributaries of the Yakima River (Table 3). Satus Creek had the highest count of kelts, 17 (28%), followed by the Naches River, 6 (10%) and Toppenish Creek with 5 (8%). The kelt tracked the furthest, was located at rkm 3.4 in Rattlesnake Creek, a tributary of the Naches River. This particular fish remained in the same stretch of river for 3 weeks before its radio tag signal was lost. In addition to Rattlesnake Creek, a radio tagged kelt was tracked into the Tieton River. This fish was observed jumping out of the water numerous times and eventually regurgitated the tag. One radio tagged kelt was detected passing Roza Dam (Rkm 205.8). This kelt was identified passing through the Roza Dam collection facility on April 11, 2002. The differences in percentages ranked per subbasin remained consistent with the Hockersmith et al. 1995 study, in which wild steelhead spawning occurred most frequently in Satus Creek, (44.7%), followed by spawning frequencies in the Naches River (36.3%), Toppenish Creek (8.7%), Upper Yakima River (7.7%) and Marion Drain (3%).

Table 3. Radio Tagged Kelt distribution per subbasin.

Yakima Subbasin		33
Lower Yakima: confluence-Naches	31	
Middle Yakima: Naches-Roza	0	
Detected in Yakima, recovered @ CJMF	2	
Upper Yakima: >Roza	0	
Satus Subbasin		17
Satus mainstem	16	
Logy Creek	1	
Toppenish Subbasin		5

Toppenish mainstem	3	
Wahtum Creek	1	
Simcoe Creek	1	
Naches Subbasin		6
Lower Naches: confluence to Wapatox	2	
Cowiche Creek	2	
Middle Naches: Wapatox-Little Naches	0	
Tieton River	1	
Rattlesnake Creek	1	

The mainstem Yakima River had just over half the detected in it 33 (54%). Of those 33 kelts, 23 moved from the release point at rkm 96.2 to rkm 112.7, 5 fell back over Prosser Dam, and 3 were detected moving up to Wapato Dam rkm 171.6. These last three fish were detected daily moving upstream, until their radio signal was lost. An additional two radio tagged kelts were recovered at CJEF fully spawned out and are currently being reconditioned a second time. These two kelts were not detected in tributaries, however, both fish were previously detected in the mainstem Yakima River and one was detected at the mouth of both Satus and Toppenish Creeks. Of the 33 mainstem detections, we only considered the 2 kelts recovered at CJEF to be spawners. We believe the remaining 31 kelts may have regurgitated their tags, fell back to the Columbia River or died. They could have traveled up tributaries and been undetected as well. Problems with the fixed telemetry sites hampered our efforts in tracking mainstem movement and some fish may have gone undetected.

Table 4. Percentages of total kelts observed in specific subbasins.

River Basin	Number of Steelhead	Percentage of Total Tagged
Naches	6	10%
Toppenish	5	8%
Satus	17	28%
Yakima	33	54%
Total Tagged	61	100%

The percentages of spawning kelts ranked per subbasin were similar to the Hockersmith et al. 1995 radio tagging study. They found that spawning occurred most frequently in Satus Creek, at

44.7%, followed by the Naches River 36.3%, Toppenish Creek 8.7%, Upper Yakima River 7.7% and Marion Drain 3% respectively (Figure 1).

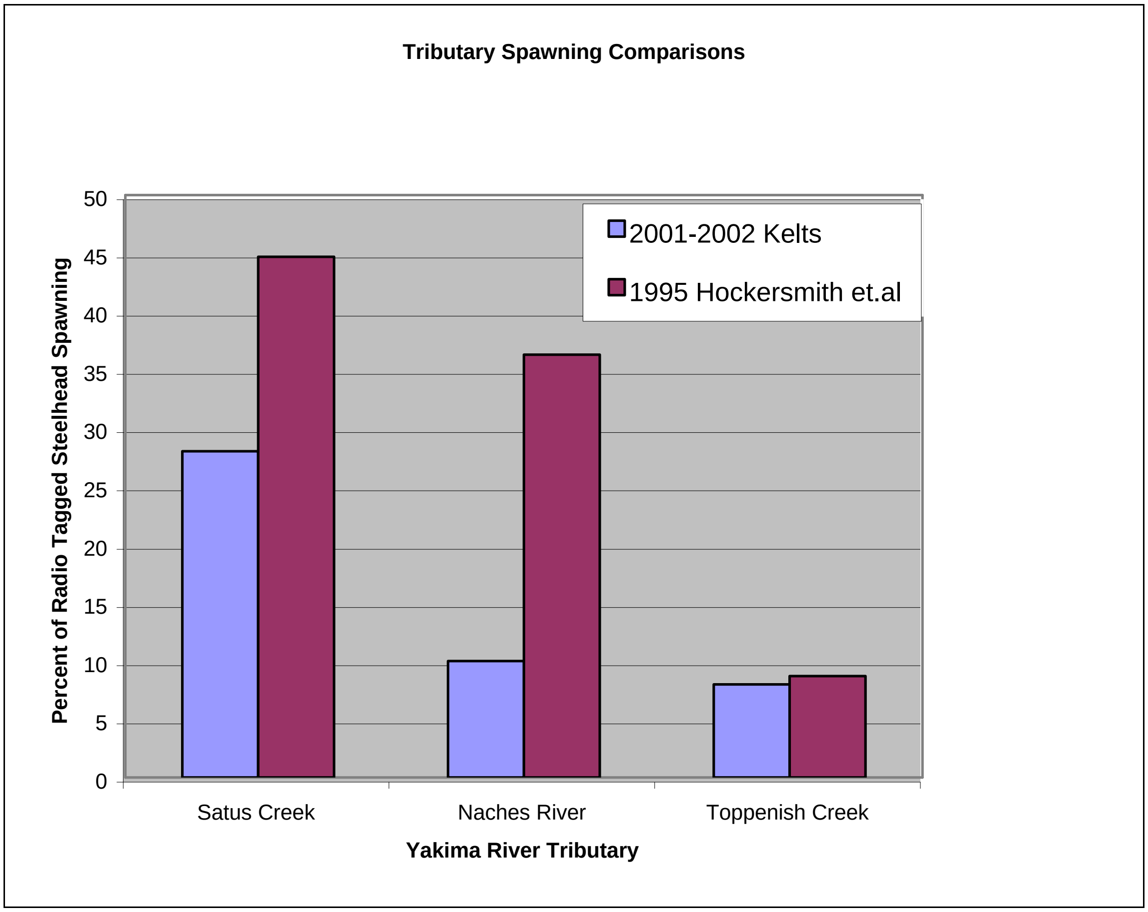

Figure 5: Yakima River tributary spawning comparisons for radio transmittered kelts in 2001-02.

The overall extrapolated spawner estimates were broken down into three categories that ranged from a high of 50 spawners to a low of 11 (Table 5). The range of numbers involves total number of kelts detected in tributaries, the maximum number of presumed spawners observed, and the minimum number of confirmed spawners. Kelts that entered tributaries were detected once near or at the confluence of the Yakima and respective tributary. Fish that were tracked into tributaries were followed daily via mobile tracking, moving up the system. The range of numbers is given for individual interpretation. The 28 kelts that entered the 9 tributaries could have all spawned. Of the 16 kelts that were actually tracked into tributaries 6 were confirmed by visual observation to have spawned. The remaining 10 were presumed to have spawned due to active redds locations near regurgitated tags, and/or fish being found very high in stream systems where steelhead spawning was occurring. The actual extrapolation was calculated by using the percent of the radio tagged fish that spawned expanded over the total 108 kelts released. The actual number of re-conditioned kelts spawning is not less than 10%. The remaining 31 kelts that were not detected could also have spawned, however, that is purely an assumption. The most probable estimate is that between 6 and 16 of the radio tagged kelts successfully spawned. The six were confirmed and the remaining 10 tagged fish were located at or near redds or actively spawning fish.

Table 5. Estimated repeat-spawner numbers.

Extrapolation Estimates	Est. Radio Tagged Kelts, Spawning	Percent Possible Spawn	Extrapolation # Of Spawners
Total detected in Tributaries	28	46%	50/108
Maximum estimated spawners	16	26%	28/108
Minimum estimated spawners	6	10%	11/108

The empirical and estimated re-spawning rates of reconditioned kelts in this study are very encouraging. As culturing techniques improve, the success of this project will likely also improve. The success of this project has raised additional questions that will be answered in future studies. As of June 1st, 2002 we have recovered 6 first time spawner kelts from Mule Dry Creek, a tributary of Satus Creek. These fish are currently being reconditioned separately and are now feeding. If they survive the long-term reconditioning process, they will hopefully be used to address three critical uncertainties: effects of reconditioning on female fecundity, gamete quality and homing. Using new telemetry equipment and higher frequency tags proposed for 2002-2003 will make tracking more accurate and streamlined, and should provide increasingly valuable data for direct application to recovery of threatened and endangered wild steelhead populations in the Columbia Basin.

Management Implications of Kelt Reconditioning – Unlike other species of Pacific salmon *(Oncorhynchus spp.)* anadromous steelhead naturally exhibit varying degrees of iteroparity (repeat spawning). Wild steelhead populations have declined dramatically from historical levels in the Columbia and Snake rivers, for many reasons. Successful steelhead iteroparity involves downstream migration of kelts (post-spawned steelhead) to estuary or ocean environments. Thousands of kelts (i.e., post-spawned fish) of ESA-listed steelhead populations in the Snake R. and mid-Columbia River are incidentally collected each spring (March - June) in the juvenile collection systems throughout the Snake and Columbia rivers. Despite the thousands of kelts that attempt out migration, results from a telemetry study Evans et al. (2001, In Prep.) suggested that only a very small percentile (<5%) successfully navigated the Snake and Columbia River hydropower system. However, resulting data occurred during low and no-spill years. In-river survival rates of emigrating kelts may increase considerably during average and above water years since emigration paths through open spillways may be available. For this life history expression (iteroparity) to persist in future steelhead runs, successful methods must be developed to augment the current rate of iteroparity among Snake and Columbia River steelhead populations.

One novel and increasingly promising approach to effectively increase natural production of wild steelhead is to capitalize on their iteroparous life history strategy by applying steelhead kelt reconditioning. Reconditioning promotes re-initiation of feeding for kelts, enabling them to survive and rebuild energy reserves required for proper gondal development and successful iteroparous spawning. Kelt reconditioning techniques were initially developed for Atlantic salmon (*Salmo salar)* and sea-trout(*S. trutta).* Evans et al (2000) provided a comprehensive literature review of kelt reconditioning , and along with past years' success reconditioning wild Yakima River steelhead kelts, evidence supports future reconditioning research, as a potentially valuable recovery tool for threatened and endangered steelhead in the Columbia River Basin and elsewhere. This steelhead reconditioning project, initiated in 2000, identifies and systematically tests several kelt reconditioning approaches.

A benefit risk analysis was produced to more informatively assess biological, genetic, and management implications of steelhead reconditioning (See Appendix B: Kelt Reconditioning Project Scoping Document, Section II, Kelt Reconditioning Benefit/Risk Analysis).

Planning, Coordination, and Information Exchange - Goals, measurable objectives, and results of this project to date have been provided to and/or available to Columbia Basin fisheries managers, researchers, and policy personnel through a series of public meetings, and agency, tribal, and scientific meetings (e.g. CBFWA, NWPPC, and ISRP program planning and review process presentations, and regional and national American Fisheries Society meetings). All these interactions and meetings provide a large amount of planning, coordination, and information exchange benefit. As an important part of last year's annual report for this project, Evans et al. (2000) provided a comprehensive literature review on the subject of kelt reconditioning, upon which improvements in project design and operation during 2001 were based.

Finally, information exchange takes the form of written documentation (e.g. quarterly and annual project reports), including detailed evaluation of the kelt reconditioning program that have been produced (Project Scoping Document and Partial 3-Step Review Document; Appendices B and C of this report). Immediate results of this research take the form of empirical and quantitative primary data, with no restrictions on their approved use. Preliminary data reside with CRITFC, who provide public access in printed and electronic formats at BPA, CRITFC, and StreamNet websites and offices. Finally, project personnel also expect to publish results of this innovative wild fish restoration research program in a prominent peer-reviewed fisheries journal.

CONCLUSIONS

- Steelhead Kelt reconditioning shows great promise to assist restoration of imperiled wild steelhead populations in the Columbia basin, based on empirical results of this project.

  During 2000, the Yakama Nation collected 512 wild kelts (38% of the subbasin's run that year) at the Chandler Juvenile Migrant Fish Facility (JMFF) for reconditioning at Prosser Hatchery, producing a first year re-spawner rate of 10% (51/512). Subsequently, kelt rematuration rates in captivity more than doubled from 10% (2000) to 21% (2001). As previously reported by Evans et al. (2000) in this project's previous annual report, kelts reconditioned by this project will substantially bolster the number of repeat spawners in the Yakima River.

- This project is successfully refining techniques, which if further supported by additional, more rigorous future research, appear very applicable to increasing its success, and that of population enhancement efforts at larger geographic scales for wild Columbia Basin steelhead.

- In general, we feel the results of the study warrant additional research, and we are optimistic that kelt reconditioning techniques may ultimately lead to an effective management program for ESA-listed steelhead populations in the Columbia River Basin.

- Kelt reconditioning should be viewed at this time as experimental, to date quite successful, rapidly improving, and very promising. The general approach should also be viewed as one of several available research techniques to guide enhancement of steelhead iteroparity expression. This project, along with the CRITFC companion project funded by the US Army Corps of Engineers addressing steelhead kelt in-river survival and passage, and hydro system bypass studies, should collectively form the framework of a systemwide investigation of iteroparity enhancement. Implementation of best methods should be targeted following several years of rigorous, replicated studies of each approach, including ecological and economic cost/benefit analysis.

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APPENDIX A:

Annual report for section 2.2 Objective 2: Evaluate and produce specialized diets for reconditioning kelts. BPA project # 2000-017

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Preliminary work was done with the modified kelt diet from the North Attleboro National Fish Hatchery (NFH), a modified Moore-Clark Trout Brood Diet and the Moore-Clark Pedigree Salmon Brood Diet. The North Attleboro diet was modified by taking the raw fish and shrimp out and a wet fish mix along with a krill slurry were substituted. The benefits of this substitution are that processed ingredients are less likely to carry disease and the thiaminase (degrades thiamine) found in raw fish is destroyed. In addition, the Moore-Clark Trout Brood Diet was modified so that it would float and be more palatable. More wheat/starch was added so the feed would float after extrusion and the feed was top-coated with a krill-squid mixture to make it more palatable. The following tables show the composition of the North Attleboro kelt diet (Table 1), the proximate analyses of the three diets used (Table 2), select vitamins and minerals (Table 3) and the fatty acid profile (Table 4) of the three diets. The data found in Tables 3 and 4 indicate that the North Attleboro modified diet has higher levels of some of the vitamins and minerals that have been identified as being important for reproductive success (Poston and Ketola 1989; Izequierdo et al. 2001). However, the important polyunsaturated fatty acids, 20:4, 20:5 and 22:5 acids, (Johnston et al. 1987; Izequierdo et al. 2001) were higher in the Moore-Clark diets (Table 4). The North Attleboro modified diet contained approximately 14.8% n-3 polyunsaturated acids (PUFA); the modified Moore-Clark Trout Brood Diet had approximately 24% n-3 PUFA and the Moore-Clark Pedigree Salmon Brood Diet had approximately 24.6% n-3 PUFA, all on an as fed basis. These PUFA levels agree with what is commonly found in commercial and experimental diets. However prey items from the ocean can have approximately 42% n-3 PUFA (Poston and Ketola 1989). Bromage et al. (1992) suggests n-3 PUFA are required for trout broodfish. Future work with the steelhead kelts should, in part, concentrate on their long chain polyunsaturated fatty acid requirements.

Table 1: Diet composition of the modified N. Attleboro kelt diet.

N. Attleboro Modified Kelt Diet	Diet Proportions %
Ingredients	
Biodiet Starter #3	51.49
Wet fish hydrolysate	29.01
Liquid krill	7.84
Beef liver	7.65
Vitamins	0.78
Minerals	0.52
Choline	0.52
Gelatin	1.96
Vitamin C	0.18
Total	100

Table 2: Proximate composition of the three diets used in 2001 to feed the steelhead kelts at the Prosser Hatchery

Diets	Protein%		Lipid%		Ash%		Moisture%		Gross Energy (cal/gm)
	as fed	dry matter	as fed	dry matter	as fed	dry matter	as fed	dry matter	
Modified N. Attleboro Kelt	38.4	63.1	13.0	21.3	7.8	12.8	39.1	--	3360.0
Moore-Clark Kelt*	44.2	47.8	19.3	20.9	8.4	9.1	7.6	--	4964.5
Moore-Clark Pedigree Salmon Brood	46.4	48.5	28.3	29.6	9.3	9.7	4.4	--	5632.0

* Moore-Clark Kelt diet is Moore-Clark's Pedigree Trout Brood Diet reformulated so that it would float, and it was top-coated with a krill/squid mixture

Table 3: Vitamin and mineral levels checked in the three diets used in 2001 to feed the steelhead kelts at the Prosser Hatchery

Diet	Vitamins	Levels	Minerals	Levels
Modified N. Attleboro Kelt	Vitamin A	96400 IU/kg	Copper	29 mg/kg
	Vitamin E	345 IU/kg	Selenium	2.07 mg/kg
	Folic Acid	24.9 mg/kg	Zinc	460.8 mg/kg
Moore-Clark Kelt	Vitamin A	12000 IU/kg	Copper	10.6 mg/kg
	Vitamin E	457 IU/kg	Selenium	1.29 mg/kg
	Folic Acid	5.1 mg/kg	Zinc	93.6 mg/kg
Moore-Clark Pedigree Salmon Brood	Vitamin A	15900 IU/kg	Copper	13.6 mg/kg
	Vitamin E	385 IU/kg	Selenium	1.41 mg/kg
	Folic Acid	5.2 mg/kg	Zinc	135.6 mg/kg

Table 4: Fatty acid profile of the three diets used for the kelt trial at the Prosser Hatchery in 2001

Fatty Acids (%)	Modified N. Attleboro Kelt	Moore-Clark Kelt	Moore-Clark Pedigree Salmon Brood
8:0 Caprylic	< 0.01	< 0.02	< 0.03
10:0 Capric	< 0.01	< 0.02	< 0.03
12:0 Lauric	0.01	< 0.02	< 0.03
14:0 Myristic	0.44	0.89	1.55
14.1 Myristoleic	0.01	< 0.02	< 0.03
15:0 Pentadecanoic	0.05	0.08	0.10
15:1 Pentadecenoic	< 0.01	< 0.02	< 0.03
16:0 Palmitic	1.74	2.62	4.07
16:1 Palmitoleic	0.69	0.95	1.65
17:0 Heptadecanoic	0.04	0.08	0.10
17:1 Heptadecenoic	< 0.01	< 0.02	< 0.03
18:0 Stearic	0.50	0.61	0.86
18:1 Oleic	2.17	2.52	3.31
18:2 Linoleic	0.37	1.04	0.84
18:3 Gamma Linolenic	0.02	0.04	0.07
18:3 Linolenic	0.09	0.24	0.21
18:4 Octadecatetraenoic	0.14	0.35	0.65
20:0 Arachidic	0.02	0.05	0.06
20:1 Eicosenoic	0.46	0.21	0.20
20:2 Eicosadienoic	0.03	0.03	0.03
20:4 Arachidonic	0.16	0.13	0.21
20:3 Eicosatrienoic	0.01	< 0.02	< 0.03
20:5 Eicosapentaenoic	0.89	1.98	3.66
22:0 Behenic	< 0.01	0.05	< 0.03
22:1 Erucic	0.13	< 0.02	< 0.03
22:5 Docosapentaenoic	--	0.29	0.46
24:0 Lignoceric	< 0.01	< 0.02	< 0.03
22:6 Docosahexaenoic	0.94	2.12	2.62

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APPENDIX B:

- Scoping Document -

Kelt Reconditioning: A Research Project to Evaluate Enhanced Iteroparity In Columbia Basin Steelhead (*Oncorhynchus mykiss*)

Contract No. 2000-017-00

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Northwest Power Planning Council

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Scoping Document

Steelhead Kelt Reconditioning Program (CRITFC/BPA 2000-17)

I. Introduction

1. Steelhead life history strategies
    a. Diversity of life history strategies in unaltered systems
    b. Col. Basin (resident, anadromous semelparity, anadromous iteroparity)
2. Basin-wide population reductions (project rationale and justification)
3. Management context for reconditioning

   (reconditioning exists in larger context of alternative iteroparity enhancement methods e.g. kelt bypass)

II. Kelt reconditioning benefit/risk analysis

1. Intro/rationale
2. Benefit/risk analysis
    a. Demographic consequences of restoring iteroparity
    b. Genetic consequences of restoring iteroparity
    c. Ecological consequences of restoring iteroparity
    d. Pathological consequences of restoring iteroparity
3. Management Issues
    a. Evaluation of: collection, rearing, and release strategies
4. Critical uncertainties and pertinent kelt reconditioning research questions

a. Is iteroparity a heritable trait?
b. Can reconditioning increase the survival of kelts relative to natural emigration?
c. Does reconditioning decrease homing fidelity relative to natural emigration?
d. Can genetic or other data be used to assign kelts to a stock of origin?
e. What are the genetic effects of enhanced iteroparity?
f. Does kelt reconditioning provide greater enhancement of iteroparity than simply bypassing emigrating kelts around the Columbia River hydropower system?

III. Literature Cited

I. Introduction

Steelhead trout (*Oncorhynchus mykiss*) naturally exhibit a wide array of life history and reproductive strategies. Wild populations of *O. mykiss* in rivers on the Russian peninsula of Kamchatka (also referred to as *Parasalmo mykiss*) exhibit six distinct life history forms, including resident riverine and precocial riverine forms, two estuarine forms, and two anadromous forms (Saavaitava, Moscow State University, Dept. of Ichthyology, Moscow Russia, personal communication). Kamchatka steelhead also possess an array of reproductive strategies. Microchemistry analysis of fish scales revealed that anadromous Kamchatka steelhead commonly spawned 5 or 6 times, and individual fish spawned as many as 9 times (K. Kuzishchin, Moscow State University, Dept. of Ichthyology, Moscow Russia, personal communication). Iteroparity appears to be the default reproductive strategy among anadromous steelhead in coastal Kachatka river systems (M. Powell, Hagerman Fish Culture Experiment Station, University of Idaho, personal communication).

Extant steelhead populations in the Columbia River Basin also express distinct resident and anadromous life history forms, with anadromous forms exhibiting iteroparity and semelparity. Whether steelhead in the Columbia River Basin historically exhibited a greater suite of reproductive and life history traits is currently unknown. However, ecological, geomorphological, and latitudinal similarities between river systems in the Columbia Basin and Kamchatka suggest that Columbia Basin steelhead may have historically exhibited additional life history and reproductive traits. The observed reduction in the frequency and contribution of iteroparity from anadromous steelhead in the Columbia River Basin relative to unimpounded river systems in Russia and Alaska (T. Bjornn, UI, personal communication) may be due largely to mortality of out-migrating kelts at numerous hydropower dams.

The difference between iteroparous and semelparous life-history strategies likely reflects the probability of successful reproduction on more than one occasion (i.e., arduousness of spawning), and represents a tradeoff in energy allocation to gametic versus somatic mass. It follows that an individual whose energy resources are more greatly allocated to reproduction would have a lower probability of retaining the energy necessary to survive a spawning migration followed by emigration to the sea. Currently it is unknown whether all steelhead are potentially iteroparous, or if iteroparity is a heritable trait (i.e., under complete or partial genetic control). For managers this distinction is important, because anthropogenic activities could exert substantial artificial selection on this trait. Hatchery programs that utilize lethal spawning techniques could exert selection against iteroparity in two ways: 1) iteroparity is directly excluded as an option; and 2) individuals making a larger investment in gametic versus somatic mass would likely make a larger relative contribution to the next generation (i.e. such individuals would have more gametes, and hence more progeny than individuals of similar size with an iteroparous life history). The same type of artificial selection could occur for naturally spawning steelhead if emigration is either impossible, or emigration mortality has increased because of anthropogenic activities. An obvious case would be higher mortality imposed by poor downstream passage facilities at dams. For example, while repeat spawning by Snake River steelhead has been reported (Long and Griffin 1937, Whitt 1954; T. Bjornn UI, personal communication) under current conditions kelts account for only around 2% of the total adult return to the Snake River (Evans and Beaty

2001). Under these circumstances, if the ability to kelt were under genetic control, one might expect the trait to decrease in prevalence for upriver stocks in the Columbia Basin given that kelting may not be advantageous relative to greater gamete allocation expected for iteroparous individuals. If iteroparity is under genetic control, it appears advantageous to enhance iteroparity given the known impediments in the migration corridor (e.g. these are the fish that successfully negotiated the migration through the hydrosystem).

Currently, there is an increasing amount of empirical data to address benefits and risks of kelt reconditioning. Iteroparity rates for *O. mykiss* were estimated to be as high as 79% for 1994-96 in the Utkholok River of Kamchatka (MSU undated; M. Powell UI and R. Williams, ISRP pers. comm.) Reported iteroparity rates for Columbia basin steelhead (*O. mykiss*) were considerably lower, due largely to high mortality of downstream migrating kelts at hydropower dams (Evans and Beaty 2001; Evans In Review), and to inherent differences in iteroparity rate based on geography (e.g. latitudinal effect, inland distance effect; Withler 1966; Bell 1980; Fleming 1998). Chilcote (In Review) reported iteroparity rates ranging from 3 to 21% for 12 different steelhead populations in Oregon. Outmigrating steelhead averaged 58% of the upstream run in the Clackamas river from 1956 to 1964 (Gunsolus and Eicher 1970). Recent estimates of repeat spawners in the Kalama River (tributary of the unimpounded lower Columbia River) have exceeded 17% (NMFS 1996), which is the highest published iteroparity rate we found from the Columbia River Basin. Farther upstream, 4.6% of the summer run in the Hood River (above only one mainstem dam) are repeat spawners (J. Newton, ODFW, pers. comm.). Iteroparity for Klickitat River steelhead was reported at 3.3% from 1979 to 1981 (Howell et al. 1984). Summer steelhead in the South Fork Walla Walla River exhibited estimated 2% to 9% iteroparity rates (J. Gourmand, ODFW, pers. comm.), whereas repeat spawners composed only 1.6% of the Yakima River wild run (from data in Hockersmith et al. 1995) and 1.5% of the Columbia River run upstream from Priest Rapids Dam (L. Brown, WDFW, unpubl. data).

Before repeat spawners can contribute to population growth and diversity, they must first successfully emigrate to the ocean following spawning. The term “kelt” has been used to describe this unique post-spawned life history phase within salmonids. In 1999 and 2000 ultrasound and visual methods were developed – with funding from the U.S. Army Corp of Engineers – to accurately distinguish kelts from pre-spawners (mature steelhead). The ultrasound technique provided a highly accurate and non-invasive way to enumerate the abundance of kelts in the Snake and Columbia rivers basins (Evans and Beaty 2000). Using this technique, kelts were enumerated at Little Goose bypass (1999 and 2000), Lower Granite bypass (2000 and 2001), and at McNary and John Day bypass facilities (2001). Data revealed that approximately 2,780 wild kelts, equivalent to *ca.* 23% of the 1999 wild run above Lower Granite Dam, passed through the juvenile collections systems at Lower Granite and Little Goose dams in the spring of 2000 (Evans and Beaty 2001). In 2001, an estimated 4,695 wild kelts, equivalent to *ca*. 21% of the 2000 wild run, passed through Lower Granite bypass facility alone. The majority of kelts were considered to be in good morphological condition (> 70%) and the kelt run was predominately female (> 80%). A trend toward higher post-spawn female survival, relative to males, is consistent with data from other iteroparous populations (Withler 1966, Leider et al. 1986, Jonsson et al. 1991, Fleming 1998, and Niemela et al. 2000).

Despite the thousands of kelts that arrived at Lower Granite Dam in 2001, very few successfully navigated the Columbia Basin hydrosystem. Radio telemetry indicated that only 24.1% (51/212) and 3.8% (8/212) of tagged kelts released from Lower Granite Dam tailrace reached the Ice Harbor Dam tailrace and Bonneville Dam tailrace, respectively. In addition to kelt mortality associated with dam passage, depleted energy stores and physical deterioration likely constituted important mortality, compounded by fasting for many months during migration and spawning (Love 1970). However, based on the above suite of empirical iteroparity estimates, steelhead kelts in impounded areas of the Columbia basin should have significantly greater likelihood of exhibiting iteroparity if they are reconditioned in captivity, relative to their current inability to exhibit iteroparity in the impounded, post-development Columbia Basin

Kelt reconditioning promotes re-initiation of feeding, thereby enabling them to survive and rebuild energy reserves required for proper gondal development and iteroparous spawning. Kelt reconditioning techniques were initially developed for Atlantic salmon *Salmo salar* and sea-trout *S. trutta*. A review of these studies and those applicable to steelhead kelts are summarized in Evans et al. 2001. This project identifies and systematically tests several kelt reconditioning approaches.

The four possible research scenarios, listed below, are described in detail within this proposal, and are consistent with the originally designed kelt reconditioning project (BPA 2000-17 and (http://www.cbfwf.org/files/province/systemwide/projects/200001700.htm), and the projects 5-yr. Research/Implementation plan):

1) Immediate downstream transport and release below Bonneville Dam (i.e. no reconditioning).
2) Short-term (2 mo.) reconditioning, then downstream transport and release below Bonneville Dam.
3) Long-term (~ 8 mo.) reconditioning and release near the collection point for upstream migration to natural spawning areas.
4) Long-term reconditioning and captive spawning.

Initial evaluation of the first three research scenarios successfully occurred with Yakima River steelhead from 2000 to the present (Evans et al. 2001). This initial research determined that steelhead kelts can successfully: 1) re-initiate feeding in captivity; 2) survive following reconditioning and release back into the Columbia River system; 3) return as repeat spawners to their natal streams; and 4) spawn for a second time in their natal streams with wild non-reconditioned fish from the same population.

As proposed, the kelt reconditioning project (CRITFC/BPA 2000-17) will rigorously examine: 1) whether these results are repeatable across geography (among different populations on a system-wide scale) and among years; and 2) whether homing and/or egg and progeny viability are negatively affected by kelt reconditioning (http://www.cbfwf.org/files/province/systemwide/projects/200001700.htm).

Populations of wild steelhead have declined dramatically from historical levels in the Columbia and Snake rivers (Nehlsen et al. 1991; NRC 1996; *US v. Oregon* 1997; ISRP 1999). Steelhead in the upper Columbia River have been listed as endangered under the Endangered Species Act (ESA) since 1997[4]. Those in the Snake River have been listed as threatened, also since 1997[1], and those in the mid-Columbia were listed as threatened in 1999[5]. Causes of the declines are numerous and well known (TRP 1995; NPPC 1986; NRC 1996; ISRP 1999), and regional plans recognize the need to protect and enhance weak upriver steelhead populations while maintaining the genetic integrity of those stocks (NPPC 1995).

Continuing declines in wild anadromous steelhead populations throughout the Columbia River Basin have prompted mangers to develop effective strategies to maintain and increase the size and stability of imperiled wild steelhead populations. One such strategy involves the reconditioning of steelhead "kelts," those individuals exhibiting an iteroparous life history. (Reconditioning is defined as the process of inducing kelts to re-initiate feeding after spawning, and to regain weight (i.e. body condition) lost during pre-spawning fasting and immediately after spawning). Reconditioning provides one approach to re-establishment and enhancement of natural iteroparity, along with other alternatives, such as bypassing steelhead kelts around the Federal Columbia River Power System (Columbia River Hydropower System).

Initially the primary objective of this project was test the feasibility of reconditioning post-spawned wild steelhead in a captive environment, allowing them to naturally spawn a second time. Research was geared toward identifying the most effective treatments (to control pathogens), feeding regimes (to stop the senescence process), and diets. During spring of 2000, the Yakama Nation (with funding provided from this project) collected 512 wild kelts (38% of the subbasin's run that year) at the Chandler Juvenile Migrant Fish Facility (JMFF) for reconditioning at Prosser Hatchery. Upon capture, a high proportion of these kelts was emaciated, exhibited de-scaling and compromised mucosal layers, and was clearly malnourished. However, at the conclusion of the experiments (~240 days from capture), 91 fish (18%) had survived. Ultrasound examination – to determine sex and reproductive development– determined that 87 (96%) of 91 specimens were female, and we estimated 51 fish (10% of the total collected) had rematured and were ready to spawn a second time. Although rematuration rates were lower than we originally hoped, the feasibility of reconditioning summer steelhead had been confirmed.
Significant progress was made regarding feeding approaches, overall survival, and rematuration rates during the 2001 research endeavor. Overall kelt survival rates in captivity more than doubled from 18% (2000) to 39% (2001)

[4] Final Rule 8/18/97: 62 FR 43937-43954.
[5] Final Rule 3/25/99: 64 FR 14517-14528.

and rematuration rates more than doubled from 10% (2000) to 21% (2001). We were able to effectively control outbreaks of Salmincola spp.*, a parasite that can inhibit oxygen uptake in fish by attaching to the gill lamella. We developed a feeding regime that increased survival rates and rematuration rates; by providing kelts with krill as a starter food (to initiate the feeding process), followed by a more nutrient rich pellet for growth and gamete development. In addition, preliminary data on the homing fidelity of reconditioning kelts was documented using radio telemetry. Results indicated that 12 of 20 recondition steelhead released in the McNary Dam forebay successfully navigated back up the Yakima River and individual fish were subsequently observed spawning with non-reconditioned (i.e., virgin spawners) fish in Satus and Toppenish creeks (major summer steelhead spawning tributaries within the Yakima watershed).*

During 2001, CRITFC personnel produced a draft genetic benefits/risks analysis report, which will be completed as in partial fulfillment of the upcoming partial 3-step process. Personnel on this project recognize that kelt reconditioning is only one component of multifaceted stock-specific and basin-wide wild steelhead restoration efforts. It is understood and appreciated that without suitable habitat and environmental conditions for spawning and rearing kelt reconditioning cannot achieve it's full restorative potential.

Preliminary results from 2002 also showed dramatic increases in success of the kelt reconditioning program: 81% kelt survival (162 of 200) was documented in a 4 week short-term reconditioning experiment at the Prosser Hatchery, of which 24% of 162 kelts (38) gained weight after re-initiating feeding in captivity. These 162 fish were transported around the hydro system and released downstream from Bonneville Dam to evaluate short-term reconditioning's contribution to iteroparity while factoring out direct hydro system mortality. As of May 28, 2002, 8 week (short-term) reconditioning treatment resulting in 85% kelt survival (170 of 200 fish). One hundred and seventy kelts from the 8-week reconditioning treatment were transported around the hydro system and released downstream from Bonneville Dam. Nearly 96% of the 170 surviving kelts reinitiated feeding and 66% gained weight in captivity during the 8-week reconditioning experiment.

Our companion kelt study on the Snake River (Corps funded) has also generated valuable data. In addition to providing information on abundance and evaluating the use of transportation to augment repeat spawners, data on the downstream survival of kelts in the mainstem hydro system were gathered (Results presented in mainstem proposal Part 2, section b: Technical and/or scientific background; (http://www.cbfwf.org/files/province/systemwide/projects/200001700.htm). Furthermore, data on kelt run timing, age structure, sex ratio, and morphology were produced (Evans 2002 in review). In 2002, project personnel are also collecting fin clips (for DNA analysis) and scales (to determine age) from kelts captured at Lower Granite Dam to evaluate quantitative life history differences between kelts originating from different spawning aggregates. If observed, a quantitative difference in age structure, in concert with genetic differentiation, could be used to assess conservation priorities for naturally spawning steelhead stocks. Data are currently also being collected to estimate current repeat spawning rates of Snake river steelhead populations via the PIT-tagging of kelts and the subsequent interrogation of tags at mainstem fishways (e.g. Bonneville, McNary, and Lower Granite Dams).

In order for reconditioning programs to be implemented with steelhead stocks listed under the Endangered Species Act, analysis of their benefits and risks must be completed. In anticipation of the need for such a document, we have evaluated data gaps and formulated research programs to address critical uncertainties necessary to evaluate kelt reconditioning programs. This document: 1) provides qualitative risk assessment of demographic, genetic, and ecological aspects of kelt reconditioning; 2) addresses pertinent management issues; 3) presents and discusses pertinent kelt reconditioning research questions and critical uncertainties. This document supplements additional information regarding direction, rationale, and justification of the kelt reconditioning program in the form of the project's Five Year Research/Implementation Plan (Beaty and Evans 2000) and project annual reports (Evans and Beaty 2001), the Project 2002 Statement of Work, and the kelt reconditioning Mainstem/Systemwide proposal (http://www.cbfwf.org/files/province/systemwide/projects/200001700.htm).

II. Kelt reconditioning benefit/risk analysis

1. Introduction

The NPPC produced a memo on October 24, 2000 stating that future project funding would depend on the results of a "partial" three-step review of Project 2000-017-00. The Council's memorandum acknowledged that the project had developed an extensive study plan that "is adequate, with supporting documents, to address the technical questions asked as part of a partial type step review."

We provide this document to meet the Council's requirement of a partial three-step review. This document contains:

1. A benefit / risk analysis of steelhead kelt reconditioning.
2. Evaluations of pertinent management issues associated with reconditioning
3. Presentation and discussions of critical uncertainties and pertinent kelt reconditioning research questions and issues.

2. Benefit/Risk Analysis

a. Demographic Consequences of Enhancing Iteroparity

Natural iteroparity represents an advantageous reproductive strategy resulting from many generations of natural selection. Further described in this document's subsequent sections, expression of iteroparity by wild steelhead in the Columbia River Basin has been moderately to severely curtailed by many factors, including development and operation of the Columbia River hydropower system. During 2001 alone, 15,112 steelhead kelts were interrogated at the juvenile fish bypass facility of Lower Granite Dam (LGR) on the Snake River, of which over 94% (14,205) were estimated to be kelts by visual and ultrasound examination techniques (A. Evans, CRITFC, personal communication). Recognizing that the juvenile bypass facility at LGR was not designed to collect out-migrating kelts, and assuming that the 2001 interrogation and kelt numbers may have represented 20-25% of all kelts arriving at LGR during their out-migration after spawning, as many as 40,000 to 65,000 kelts may have attempted outmigration after spawning in the Snake River Basin upstream from LGR. Given that current iteroparity rates in the Snake River are very low (about 1%), we can be fairly certain that kelting is being effected more by challenges to migration than by loss of the desire to migrate. Furthermore, over 15,112 steelhead were collected during 2001 at the juvenile fish bypass system, of which over 94% (14,205) 1 estimated to be kelts based on ultrasound and visual examination (A. Evans, CRITFC, personal communication)

Thus, reconditioning, as a means to enhance the prevalence and success of natural iteroparity provides great promise to increase natural production in wild steelhead population in the Columbia Basin, with minimal intervention. Accordingly, demographic consequences of enhancing an artificially reduced natural reproductive trait appear to largely exist in a no-net-negative context. However, the goal of this document is to objectively address potential benefits and risks of kelt reconditioning as applied to imperiled wild steelhead in the Columbia Basin.

Empirical regulation of population growth rates before implementation of a reconditioning program will ultimately determine whether the benefits are likely to outweigh the risks. In a declining population, family lines and their associated genetic variation may be lost over time, since some families will not produce offspring that survive to spawn in the next generation (Kelly 2001). Under these circumstances, a kelt reconditioning program has the potential to substantially decrease the potential for lineage loss by increasing the productivity of reconditioned individuals. However, when a population is suffering a substantial decline, the potential risk of over-representing particular genotypes by reconditioning a subset of the population may not present a higher risk than not implementing a reconditioning program. This is because in the absence of a reconditioning program, lineages may disappear, resulting in over-representation of the remaining genotypes (i.e., the same end result, simply a different mechanism). Alternatively, if a population exhibits a stable or increasing growth rate, the risk of losing lineages is reduced, because it is more likely that more (all) families will produce offspring that return to spawn in the next generation. Thus, the proportion of the population captured and incorporated into a reconditioning program is the primary factor controlling the magnitude of program benefits and risks.

Potential benefits and risks of a reconditioning program are also influenced by how well the reconditioning program demographically and genetically represent the targeted population(s). When a population is declining, the benefits of a kelt reconditioning program may outweigh the risks of not implementing a program, due to the potential for loss of lineages in the absence of the program. However, if a population is stable or increasing, the risk of over or under-representing genotypes increases as capture efficiencies or survival during captivity decrease. Consequently, reconditioning is proposed only for declining and imperiled wild steelhead populations in the Columbia Basin.

Finally, regardless of population growth rate, if kelting is a heritable trait, a reconditioning program may provide the only immediate means to avoid further erosion of genetic variation coding for iteroparity when anthropogenic changes severely limit or prohibit its expression. If the ability to kelt is a quantitative trait, relative risks of kelt reconditioning may be minimal compared to the alternative reduction or loss of the iteroparous life history strategy, and its possible effects on population demographics.

b. Genetic Consequences of Enhancing Iteroparity

Genetic risk is a relatively ambiguous term used to express the valid concern that genetic properties of native fish populations may be harmed by fish introductions or other management activities. Busack and Currens (1995) provided a useful approach to reducing this ambiguity, and addressed this issue by incorporating the words ‘hazard” and “risks” in a simply defined context. A hazard is simply defined as a potentially adverse consequence of an event or activity, whereas risk is the probability of that hazard occurring. A commonly cited example of a genetic hazard associated with cultured fish populations is the potential loss of within-population genetic diversity (Ward and Grewe 1994 and references therein).

In any management scenario it is important to realize that the risk associated with any hazard becomes increasingly irrelevant as the probability of its occurrence approaches zero. Alternatively, a higher probability of occurrence of a particular hazard constitutes greater risk. Busack and Currens (1995) reported four prevalent genetic hazards associated with hatchery operations: extinction, loss of within- and among-population variability, and domestication. Inbreeding constitutes another important genetic hazard, and is incorporated into subsequent discussions of these four genetic hazards. Taken largely from Busack and Currens (1995), we now define these genetic hazards, and present a brief description of associated mechanisms. This is followed by: 1) a brief discussion of their relevance to the steelhead kelt reconditioning program (CRITFC/BPA 2000-17); and 2) an associated qualitative risk value (low, moderate, or high) for each of these four genetic hazards.

Genetic Hazard 1: Extinction

1a) <u>Extinction</u>: Complete loss of all genetic information

Extinction represents the most severe hazard. Because multiple populations of any species may represent differing gene pools to varying degrees, extinction of any population may also reduce among-species variability, and possibly the overall diversity of the species. This is true whether populations exhibit gene flow, meta-population structure, or are allopatrically distributed.

1b) <u>Mechanisms</u>

Extinction differs from other genetic hazards because it is often proximately caused by non-genetic mechanisms. Although extinction has often been attributed to problems associated with low genetic diversity and variation, those genetic signatures frequently result from prior reductions in population size caused by non-genetic factors (e.g. habitat loss and degradation, overharvest, Allee effects). However, in later stages of population collapses, genetic mechanisms can further reduce reproductive success and population viability and persistence (e.g. inbreeding depression, drift in small populations, resulting in loss of within- and possibly among-population variability and diversity). This concept has been described as the extinction vortex (Gilpin and Soule 1986).

1c) Relevance of Extinction to Steelhead reconditioning project

Reduction of extinction risk for wild steelhead populations is the ultimate driver of the steelhead reconditioning program. Population enlargement and increased within-population gene flow are expected benefits of kelt reconditioning by design, incorporating important links with maintenance and protection of locally adapted population genetic signatures.

1d) Qualitative Extinction Risk Assessment Risk – Low

Projects such as reconditioning, which enhance wild populations' advantageous life history and reproductive characteristics do not pose an extinction threat to wild populations, they are designed and intended to reduce that threat. The reconditioning project is utilizing individuals that would typically no longer contribute to population growth because of the very low realized repeat spawning rate under current conditions, and is assisting them in making a meaningful contribution to the population growth through restoration of an advantageous natural life history attribute.

Genetic Hazard 2: Loss of within-population genetic variability

2a) Loss of within-population genetic variability: Reductions in quantity, variety, and combinations of alleles within populations

2b) Mechanisms

The following mechanisms also apply to the third genetic hazard: loss of among-population genetic variability and diversity.

i. Genetic drift

Genetic variability (e.g. composite haplotype/genotype frequency distribution) and genetic diversity (total number of haplotypes) can be reduced in populations by random genetic drift because during spawning more gametes are produced by parents than may actually unite, develop, and survive as progeny (also know as sampling error). Negative effects of drift become increasingly deleterious and significant when population size declines. Furthermore, a "family effect" may be exhibited, whereby as populations get progressively smaller the degree of relatedness among remaining individuals in the population tends to increase. Such changes may subsequently increase the probability of inbreeding (and inbreeding depression), resulting in net losses of individual and population fitness (Kelly 2001).

ii. Inbreeding

Inbreeding is the breeding of closely related individuals. Inbreeding in and of itself does not lead to changes in frequency or variety of alleles (Falconer 1981). Rather, inbreeding increases individual and population homozygosity because more closely related individuals are more likely to share the same alleles than are more distantly related individuals. If selection and drift act upon such populations, allele frequencies can also change, increasing the probability of losing rare types, thus reducing within- and possibly among-population genetic variability.

iii. Artificial selection

In a given year if all spawners are captured after spawning, and all of the captured adults survive to spawn as kelts, there is little risk that some genotypes will be over-represented relative to others. However, as capture efficiency and survival during captivity decrease, the risk of over or under-representing genotypes increase. To date, empirical survival of Yakima River steelhead kelts during reconditioning has been very high. During 2002, survival rates of reconditioning kelts from the Yakima River at the Prosser Hatchery (4 and 8 week treatments) were 81% and 86% respectively (YN/CRITFC, unpublished data). Selection issues become more relevant when evaluating the use of reconditioning in larger populations, which may exceed a program's logistical ability to incorporate the entire population. In such cases, relative benefits of reconditioning must be weighed against risks resulting from a lack of program implementation on a case-by-case basis.

2c) Relevance to Kelt Reconditioning

The observation that consistently > 90% of all kelts collected to date in the reconditioning program on the Yakima River were females (YN/CRITFC unpublished data) suggests that this program presents very little risk in the form of reduced within-population variability as could occur by artificially enhanced inbreeding. Conversely, the kelt reconditioning program provides opportunities to enhance historic gene flow within wild steelhead populations; essentially female iteroparity prevents multiple spawnings of male and female siblings or cohorts. Predominantly female iteroparity may represent a reproductive strategy by which the frequency of inbreeding was naturally curtailed in wild steelhead populations.

2d) Qualitative Risk assessment Risk - Low

The probability of kelt reconditioning causing loss of within-population genetic variability is low. Potential benefits (increased within population gene flow; increase in demographic vigor, population viability and persistence) appear to outweigh risk of losing within-population variability (low probability). However, more accurate benefit/risk analysis could be pursued on a population-specific basis.

Genetic Hazard 3: Loss of among-population variability

3a) Loss of among-population variability

The among-population analogue of within-population loss of variability (Genetic Hazard 2). Loss of among-population variability could reduce fitness and adaptive potential at the species level if enough populations experience such losses, or if individual populations exclusively possess unique genetic material.

3b) Mechanisms

This hazard can be realized by simultaneous reductions in variability within individual populations or among all populations by mechanisms of inbreeding, artificial selection and genetic drift (See Section 2b, above for further details on these mechanisms).

3c) Relevance to Kelt reconditioning project

As with Genetic Hazard 3 (loss of within-population variability), Kelt reconditioning (as proposed in 2002 with multiple wild populations) appears to contribute to among-population variability rather than reduce it, or at worst have no positive or negative effects.

3d) Qualitative Risk Assessment Risk - Low

Probability of a kelt reconditioning project reducing among-population genetic variability appears low. Potential benefits (increased within population gene flow; increase in demographic vigor, population viability and persistence) appear to outweigh potential risks of losing among-population variability (low probability).

Genetic Hazard 4 – Domestication

4a) Domestication

Domestication is defined as changes in behavior, phenotype, and/or quantity, variety, or combination (frequency) of alleles within a captive population or between a captive population and its source population resulting from selection in an artificial environment (e.g. hatchery setting).

4b) Mechanisms

Intentional or unintentional artificial selection for potential subsets of individuals in an artificial/ hatchery environment (e.g. aggressive behaviors, reduced predator avoidance behaviors, upper water column position maintenance) represents the main mechanism resulting in domestication.

4c) Relevance to Kelt reconditioning project

Domestication risk (probability of domestication occurring) appears very low due to the relatively brief periods of time kelts spend in captivity (relative to majority of their lives spent in the wild under selection). In addition, all kelts being reconditioned are wild-origin fish that are released prior to spawning. Kelt mortality due to domestication (if it exists) may be more than compensated for by kelt survival in lieu of mortality while out-migrating in the Columbia River hydropower system. Kelts in the reconditioning program have successfully exhibited natural rearing, out-migration, survival in the ocean, and have successfully returned to spawn, and out-migrated from natal streams after spawning, providing direct evidence of fitness. Furthermore, because kelts are reconditioned for only 8 weeks or for 6 months, and because they are at a point in their life cycle where all required behavioral survival and reproductive traits were successfully exhibited, domestication risk appears very low. However, this prediction will be tested by analysis of empirical return/survival data from reconditioned kelts.

4d) Quantitative Risk Assessment Domestication Risk – Low

Potential benefits of kelt reconditioning program (increased within population gene flow; increase in demographic vigor, population viability and persistence) appear to outweigh potential negative effects of domestication (probability of domestication low).

Additionally, potential genetic consequences of increasing the rate of iteroparity include: increased probability of maintaining matrilines; potential to increase the abundance of genotypes of individuals exhibiting iteroparity; and increased probability of maintaining the quantitative genetic variation coding for iteroparity, if it is a heritable trait. In general, the benefit of increasing iteroparity is a decrease in potential loss of genetic variation (i.e., spreading the risk in a stochastic environment), while the risks of increasing iteroparity include the potential for artificially over-representing particular genotypes (by allowing repeated spawning by individuals selected for reconditioning). In practice, the population growth rate and the proportion of a spawning cohorts surviving to repeat spawn will also control the genetic risks and benefits of reconditioning.

c. Ecological Consequences of Enhanced Iteroparity

The greatest ecological consequence of increased iteroparity is the potential for increased natural productivity of wild steelhead populations in the Columbia River Basin. If an individual female spawns twice, her productivity could be up to twice that of a semelparous female. Restoration of this beneficial natural strategy can be multiplied by the numbers of fish successfully reconditioned which spawn more than once. This phenomenon provides demographic and genetic benefits in the forms of increased population size, effective population size, and annual number of breeder, and increased within-population gene flow due to reconditioned females mating more than once and with males from different cohorts within the natal environment.

Increased productivity is especially important in a stochastic and artificially altered environments. Both conditions apply to wild steelhead populations in the Columbia Basin. If poor environmental conditions result in high mortality during a given year, the ability to spawn repeatedly could increase the probability of successful reproduction in the following year if environmental conditions improve. Likewise, if altered environmental conditions have had negative effects on natural production, multiple spawnings may provide increased natural production to some degree compensating for effects of that alteration. Therefore, an increase in the rate of posthydropower system iteroparity could increase the probability of persistence in altered, stochastic environments. Furthermore, because kelt reconditioning is designed to reestablish and/or enhance iteroparity reduced by the Columbia River hydropower system to levels presumably below (peak) historical levels, ecological risks (e.g. overseeding, artificially elevated competition) may be somewhat irrelevant, relative to cases of increasing production beyond historical capacity or current ecological limitation.

d. Pathological consequences of restoring iteroparity

Disease-associated mortality represents a potential hazard to restoring and rebuilding depressed anadromous salmonid populations. With the listing of a number of salmonid stocks under the Endangered Species Act (ESA) and the establishment of captive broodstock and kelt reconditioning programs to preserve genetic integrity of select stocks, the threat of disease and the impact it could have is a valid concern. A number of fish pathogens are difficult to control as they can be transmitted vertically (from parent to progeny) either on or within the eggs, or can affect valuable broodstock directly. If immunity could be enhanced in adult fish, the risk of disease would be reduced. The mechanisms of such a strategy can be identified and it is speculated that enhanced immunity will inhibit pathogen involvement in vertical transmission and may enhance early protection through maternal transfer of immunoglobulin (Ig) to the eggs and fry (Ken Cain, University of Idaho, personal communication).

Regarding fish health, mangers should consider two issues: 1) the possibility that disease transfer during rearing could result in lower kelt survival relative to natural emigration; and 2) that release of reconditioned kelts and/or their progeny will increase the prevalence of disease to natural populations (e.g., as a result of horizontal transmission during captivity). If capture and handling of steelhead kelts increases their susceptibility to disease outbreak, and a pathogen is present within the rearing facility, it is possible that horizontal transmission (Snieszko 1973) could result in a higher prevalence of disease among kelts retained for reconditioning than among kelts allowed a natural emigration. Recent (2002) survival rates of reconditioning kelts in captivity ($\leq$ 8 weeks) ranged from 81 to 86%, initially indicating that disease did not represent a major risk for kelt survival. However, from a demographic perspective, disease would only be detrimental *per se* if either the total number of kelts surviving to spawn were decreased as a result of disease transmission during captivity, or if released adults and or their progeny introduce a new disease or increase the prevalence of disease in a naturally spawning population.

3. Management Issues

Collection Strategies

Kelt collection could occur at the level of individual tributaries, subbasins, or river basins, in the last case collected at mainstem dams. Potential benefits and risks of these strategies depend on: 1) the geographic scale and relevance of population structure; 2) the geographic scale on which managers require information on homing; 3) the degree to which mangers wish to limit mortality; and 4) labor, cost, capture location, and logistical constraints.

Population Structure

The geographic scale of biologically meaningful population structure might be used to guide the positioning of kelt collection facilities. For example, if data suggest that biologically meaningful differences between spawning aggregates occur at the level of individual tributaries, managers may wish to position a kelt collection facility below the spawning grounds within individual tributaries. Doing so would allow managers to ensure that each spawning aggregate is represented in the kelt reconditioning program. Alternatively, collection strategies occurring at a larger scale may result in under or over-representation of certain spawning aggregates, due to differential mortality or differential stock-specific capture efficiencies. However, if large-scale collection strategy is employed, managers must ensure that collection facilities do not impede passage of pre-spawn adults, or that the appearance of “false” population structure does not lead to management-induced fragmentation. In other words, if population structure is defined genetically, and a sampling bias leads to a false interpretation of genetic structure, finely-scaled collection programs may lead to fragmentation of a continuous or sympatric population.

Alternatively, if data suggest that spawning aggregates inhabiting individual tributaries are members of a metapopulation, mangers may wish to collect steelhead at the subbasin level, while evaluating potential effects due to differences in stock-specific capture efficiencies. Although such a collection strategy would yield less detailed information about kelt productivity and homing, and a higher likelihood of over or under-representation of some spawning aggregates, the risk of artificially fragmenting a continuous population is decreased.

Finally, for a variety of reasons[6], mangers may wish to pursue collection of kelts at a mainstem location at the basin scale (e.g., a mainstem Snake River or Columbia River dam). Such a collection strategy presents the greatest risk of under or over-representation of certain spawning aggregates. Numerically depressed stock or stocks with temporally abbreviated outmigration may be most prone to such misrepresentation. Furthermore, if kelts are collected at Lower Granite Dam, passage mortality occurring at upstream dams will almost certainly result in a relative under-representation of spawning aggregates that must pass multiple dams before reaching a downstream collection point.

Rearing Strategies

Three classes of rearing are generally considered for kelt reconditioning programs: 1) capture, transport, and immediate release; 2) capture, short-term rearing, and release before re-maturity; or 3) capture, rearing until maturity and spawning or release. The choice of rearing strategy depends on the release strategy selected. Risks to be evaluated for each rearing strategy include: 1) disease (see section II, 2, d); 2) mortality (higher or lower than without collection and reconditioning); and 3) potential for artificial selection.

Direct or incidental mortality resulting from collecting and handling kelts could pose an increased mortality risk relative to natural emigration. For example, if handling increases disease susceptibility, or if capture facilities

[6] For example, kelts have been observed to delay emigration for 6 to 8 months (Shapovalov and Taft 1954), which may limit the ability of mangers to collect kelts from headwater traps.

impede normal emigration or immigration by steelhead and/or kelts, mortality could potentially be increased relative to no kelt collection. However, loss to collection and handling must be compared to "control" or baseline mortality of kelts allowed to emigrate through the Columbia River hydropower system to fully evaluate benefits and risks associated with handling mortality in kelt reconditioning programs.

The potential for artificial selection may exist at many points in a kelt reconditioning program. Capture strategies may inadvertently select for the largest individuals, and rearing may select against those adults that refuse artificial diets. Artificial selection during capture can be avoided to a large degree by randomly retaining kelts for reconditioning from the temporal duration of the run, or by capturing all available kelts. In general, if mortality of captured adults is low and there is little risk of artificial selection during captivity, the genetic composition of the stock should not be significantly altered. If mortality during captivity is high, mangers could implement a natural reconditioning program, similar to the NATURE's rearing programs used in supplementation hatcheries (Maynard *et al*. 1996), aimed at reducing mortality during reconditioning. For a kelt reconditioning program, mangers might choose to introduce natural feeds, acclimate kelts to seawater, and/or maintain natural substrates and cover in rearing pools.

Experiments are ongoing at the Prosser Hatchery to evaluate effects of improved reconditioning facilities (density, tank coloration and covering) and transition to fortified, nutritionally balanced diets.

Release Strategies

In general, release strategies can be summarized as: 1) release of kelts before re-maturity; 2) release of mature kelts; or 3) spawning of kelts and release of their progeny. Ultimately, the goal of kelt reconditioning is to increase the abundance of repeat spawners on the spawning grounds. A second goal may be to provide broodstock for hatchery programs as an alternative or addition to collecting exclusively first-run adult steelhead. In order for a reconditioning program to be beneficial, the abundance of kelts and their progeny must increase relative to abundance without a program. As it pertains to release strategies, risk factors include the potential for artificial selection, and the potential to increase straying compared to natural kelt emigrants.

In general, artificial selection can be minimized by proper collection techniques (as discussed previously) and minimizing time in captivity. Minimizing time in captivity decreases the period of time adults are subjected to an unnatural environment and associated selection pressures. For example, if kelts are collected and immediately transported and released in the estuary, there would be very little time for selection to act against adults that exhibit poor survival in captivity. Alternatively, if kelts are held until re-maturation (approximately nine months), selection could result in the mortality of adults that do not accept artificial feed, or exhibit poor survival in captivity. In general, if kelts were released to spawn naturally, they would be subjected to the same assortative mating as other naturally spawning adults, hence decreasing the risk of artificial selection relative to artificial spawning (Bielak and Davidson 1993). Finally, kelts held until mature and artificially spawned would be subjected to the greatest potential for artificial selection, and the progeny of these adults would be subjected to the same risks of artificial selection as progeny from ordinary hatchery programs that use wild broodstock.

4. Critical Uncertainties and Directions for Kelt Reconditioning Research

Currently, mangers have increasing amounts of empirical data to assess benefits and risks of steelhead kelt reconditioning. However, given the tremendous potential benefits of kelt reconditioning and alternative methods to restore and enhance iteroparity, we suggest that further research is warranted. The previous discussion suggests a number of critical uncertainties requiring research:

a) Is iteroparity a heritable trait?

b) Can reconditioning increase the survival of kelts relative to natural emigration?

c) Does reconditioning decrease homing fidelity relative to natural emigration?

d) Can genetic or other data be used to assign kelts to a stock of origin?

e) What are the genetic effects of enhanced iteroparity?

f) Does kelt reconditioning provide greater enhancement of iteroparity than simply bypassing emigrating kelts around the Columbia River hydropower system?

a. Is Iteroparity a Heritable Trait?

The degree to which the ability to kelt is heritable has not to our knowledge been systematically addressed, and is a critical uncertainty for evaluating the benefits and risks of reconditioning programs. If the ability to kelt is heritable, reconditioning programs may provide a means to ensure that the genetic variation coding for the trait is not lost in populations for which kelting is prohibited as a result of anthropogenic factors (e.g. turbine mortality at mainstem dams for emigrating kelts (Evans and Beaty 2001); lethal spawning in artificial production programs). The ability to directly address the heritability of kelting is limited, therefore we recommend that managers consider the following two experiments to further assess the heritability of kelting.

Kelt Heritability Experiment One: Environmental Discrepancy

If kelting is a heritable trait, lethal spawning techniques typically employed in supplementation programs should directly select against kelting. Therefore, if kelting is heritable, we would expect the proportion of naturally spawning, hatchery-origin kelts to be lower than that in a natural population. To test this hypothesis, mangers could determine and compare the number of hatchery-origin adults available to spawn in the wild (e.g., Lower Granite Dam hatchery steelhead count minus returns to the hatcheries minus fishing mortality) and the number of hatchery-origin kelts attempting to emigrate past Lower Granite Dam. The result should provide an estimate of kelting rates based on the total number of hatchery-origin adults available for natural spawning. Mangers could compare the hatchery-origin kelt estimate against a natural origin kelt estimate (calculated in the same manner) to determine whether the proportions differ. If hatchery-origin and natural-origin steelhead have similar natural pre-spawning mortality rates, and the number of hatchery-origin kelts is proportionally lower than natural-origin kelts, it would suggest that lethal spawning of steelhead broodstock may be having a genetic impact on the ability of steelhead to exhibit iteroparity.

Kelt Heritability Experiment Two: Long-Term Monitoring of Kelt Proportions in a Population Targeted for Reconditioning

A more compelling, but much longer-term experimental approach to determine heritability of kelting involves monitoring the proportion of a population that exhibits iteroparity over the course of a reconditioning program. For example, if kelting is heritable, but a population is impacted such that the ability to express iteroparity is limited (e.g., located above a dam with poor emigration facilities), one would expect the proportion of the population expressing iteroparity to decrease over time, as selection would act to decrease genetic variation coding for the trait. If a reconditioning program is implemented for such a population, the prevalence of repeat spawning would be expected to increase, with a concomitant increase in the prevalence of genetic variation coding for the trait (i.e., iteroparity could become a “profitable” strategy). Therefore, we expect that the abundance of first-run steelhead exhibiting a post-spawning kelt life history would increase over the course of a reconditioning program.

b. Can Reconditioning Increase the Survival of Kelts Relative to Natural Emigration?

For a reconditioning program to be considered successful, it must increase the number of steelhead which successfully kelt and reproduce. To determine if reconditioning is successful at increasing survival to repeated spawning, we recommend that a known proportion of post-spawn first-run (not repeat spawners) steelhead from a natural population be randomly retained for reconditioning. The proportion of reconditioned kelts versus non-reconditioned kelts that return the subsequent year could determine the survival of reconditioned kelts relative to naturally emigrating kelts. This research is ongoing with wild Yakima River steelhead as part of the Yakama Nation’s Fisheries Program at Prosser Hatchery (CRITFC/BPA Project 2000-17).

c. Does reconditioning decrease homing fidelity relative to natural emigration?

Homing fidelity in Pacific salmonids appears largely due to the successful completion of imprinting events at various early life stages in the natal stream environment and during the smolt and out-migration processes (Quinn et al. 1990; Brannon and Quinn 1989, Hasler and Scholz 1983). To determine if kelts exhibit the ability repeatedly home their natal stream, we recommend that mangers implant radio transmitters in pre-spawn steelhead, pre-spawn natural kelts, and pre-spawn reconditioned kelts captured at a common location (e.g., tributary dam or trap). All study groups could be transported to a downstream release location, and their relative rate of return to the capture location (i.e., in-season homing) could be used to determine if kelts stray at a greater rate than first-run steelhead and the relative rate of in-season homing of reconditioned versus natural kelts. Recent telemetry revealed that during 2001, 12 of 20 reconditioned steelhead (60%) tagged with radio transmitters and released in the McNary Dam forebay successfully returned to the Yakima River (A. Evans, pers. comm.), despite concerns regarding temperature differentials between the Yakima and Columbia rivers, which could have precluded or delayed the fishes’ spawning migration into the Yakima system.

d. Can genetic or other data be used to assign kelts to a stock of origin?

Depending on the capture location and release strategies employed in reconditioning programs, it may be beneficial for mangers to have the ability to assign reconditioned kelts to a stock of origin. For example, if kelts are collected at Lower Granite Dam, and mangers wish to spawn kelts in captivity for the purpose of releasing progeny into the population of origin, it is necessary to ascertain the stock of origin for reconditioned kelts. For kelts lacking a stock specific mark (i.e., natural-origin kelts), it may be possible to assign these individuals to a stock of origin using genetic data. To do so, mangers would require a baseline genetic sample from hatchery and natural populations upstream of the kelt capture location. Using assignment algorithms such as WHICHRUN (Banks and Eichert 2000), mangers could use genotype frequency data to assign captured kelts to the most likely populations of origin. (See above Section II, 2, b. "Genetic consequences of restoring iteroparity" for a more comprehensive evaluation of genetic consequences).

e. What are the genetic effects of enhanced iteroparity?

It is currently unknown whether increasing the prevalence of iteroparity will accelerate or slow the loss of genetic variation, or whether it may increase diversity or variation. The answer largely depends on the size of the population, its present genetic diversity and variability, and the proportion of the population that is incorporated into a kelt reconditioning program. However, increasing gene flow among individuals within a population through reestablishment of a selected, potentially heritable trait (iteroparity) may be beneficial relative to protecting, maintaining, or even increasing within-population genetic variability. Expanding this evaluation to additional populations could provide the same beneficial effect at regional, stock, or species levels.

Given that the maintenance or loss of genetic variation may or may not be directly quantifiable, we recommend that mangers consider the use of simulation models to estimate changes in genetic variation coinciding with increased iteroparity. Several scenarios could be modeled, including but not limited to: increasing and decreasing population growth rates; a range of reconditioning success or failure scenarios (e.g., complete mortality of reconditioned kelts to 100% successful spawning of reconditioned kelts); a range of capture efficiencies (e.g., few captured and reconditioned kelts to 100% capture and successful reconditioning); and a range of natural kelting values (e.g., all natural kelts die during emigration to 100% success of natural kelts).

6. Does kelt reconditioning provide greater enhancement of iteroparity than simply bypassing emigrating kelts around the Columbia River hydropower system?

This question will be directly addressed by the kelt study's Mainstem/Systemwide research proposal: (http://www.cbfwf.org/files/province/systemwide/projects/200001700.htm). *If bypassing emigrating kelts around the Columbia River hydro system by barge or truck provides equivalent increases in natural* *production as reconditioning, at a lower cost, reconditioning may be a less desirable method to enhance iteroparity. Conversely, standardized cost/benefit analysis could indicate that reconditioning is a more effective means to enhance natural production by increasing the expression of iteroparity. Ongoing and proposed evaluations of kelt reconditioning and bypass are designed to facilitate such comparisons (CRITFC/BPA Project 2000-17 and CRITFC/Corps funded kelt bypass and telemetry studies on the Snake River).*

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APPENDIX C:

- Partial 3-Step Review Process Document -

Kelt Reconditioning: A Research Project to Evaluate Enhanced Iteroparity
*In Columbia Basin Steelhead (*Oncorhynchus mykiss*)*

Contract No. 2000-017-00

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October 24, 2000

MEMORANDUM

TO: Roy Beaty

FROM: Mark Fritsch

SUBJECT: Step Review for Project (#2000-017-00) - Recondition Wild Steelhead Kelts

The Council's approval on October 10, 2000 for the *Recondition Wild Steelhead Kelts* Project 2000-017-00 was conditioned on an independent scientific review, as it relates to the three-step review process, and that future funding will be dependent on the results of this review.

Due to the experimental approach of this study as it relates to the artificial production there is no need at this time to initiate a full Three-Step Review Process. Though this project does trigger a review by definition (i.e. planting fish in waters that they have not been planted in before) it does so in a very experimental and research orientated manner. If this project were to be expanded or changes in scope or size in the future it will be necessary to implement a full step review (e.g. master plan, etc). It is our understanding that the information collected during this phase will be used to address program areas pertaining to future activities and review process.

It is my understanding that an extensive study plan has been developed for this project and is adequate, with supporting documents, to address the technical questions asked as part of a partial type step review. The Council is anticipating the submittal of review documents by the end of the calendar year. This should provide adequate time for the completion of the review prior to the next funding and review process.

This review will include responses to technical questions relating to: (1) master planning requirements according to Section 7.4B of the Council's Fish and Wildlife Program **(Attachment I)**, (2) questions identified in the Fiscal Year 1998 Annual Implementation Work Plan **(Attachment II)**, (3) questions involving the Fish and Wildlife Program language identified by the Independent Scientific Review Panel **(Attachment III)**, and questions relating to the development schedule and estimated cost expenditures and future needs of your proposed project **(Attachment IV).** In addition find attached the APR policies and standards **(Attachment V)** that need to be addressed. Part of the Council's review process will include an independent scientific review of the answers to the technical questions and responses to the APR policies.

I hope that this letter clarifies the status of your project with regard to the Council's recent decision. If you have any questions, please do not hesitate to contact me.

cc: Brian Allee, CBFWA
Bob Austin, BPA
Roy Beaty, CRITFC
Bob Lohn, NPPC
Doug Marker, NPPC
Brad Miller, BPA
John Ogan, NPPC

Peer Review Questions for 3-Step Review

Attachment I: Program Language Regarding Master Planning Requirements

7.4B.1 Master Planning

Because of the need to address potential conflicts among increased production, mixed-stock harvest, gene conservation, consistency with other plans and other objectives, the Council calls for detailed master plans where there is not a National Environmental Policy Act document that provides enough information to evaluate new artificial production projects. Below, the Council provides a suggested list of master plan elements. This list is intended to offer guidance, not to impose requirements. Not all of these elements may be relevant in all projects, and some unlisted elements may be important. In general, however, the following elements should be considered in the course of master planning:

- *project goals;*

The goal of the steelhead kelt reconditioning program (Project 2000-17) is to rigorously evaluate the effectiveness of steelhead kelt reconditioning to restore and enhance the expression of iteroparity. This project proposes to continue to test and evaluate methods to recondition steelhead kelts and/or transport them around hydo system, to generate science-based management recommendations, and to assist in their implementation to rebuild wild steelhead populations throughout the Basin, if appropriate.

- *measurable and time-limited objectives.;*

The Kelt Reconditioning Program (Project 2000-17) has six measurable, time-limited objectives:

1. Evaluate effects of directly transporting Yakima River steelhead kelts around the hydro system on enhancement of iteroparity.

2. Evaluate effects of short-term kelt reconditioning and subsequent transportation of kelts around the hydro system on enhancement of iteroparity

3. Evaluate effects of long-term kelt reconditioning and subsequent release for natural spawning on enhancement of iteroparity

4. Evaluate effects of long-term kelt reconditioning and captive spawning on: a) gamete and progeny viability; b) enhancement of iteroparity (i.e. viability of virgin vs. repeat spawners)

5. Comprehensive project evaluation and recommendations.

6. Participate in NEPA and ESA permitting to the extent required to perform all aspects of steelhead reconditioning research listed under preceding objectives.

As proposed, these objectives will be addressed conclusively during the next three years.

- *factors limiting production of the target species;*

As presented in the executive summary of the National Research Council's book entitled "Upstream" (NRC 1996): "The salmon [steelhead] production cycle has three principal components that determine abundance: reproductive potential of adults returning from the sea to spawn, which is affected by their growth at sea; production of offspring from natural reproduction in streams and artificial propagation in hatcheries; and sources of mortality (including natural mortality, fishing mortality, dam-caused mortality, mortality from habitat alterations and changes in environmental conditions and so on). Variation in the three components and their interactions ultimately determine the ability to sustain salmon populations and their production".

In the case of steelhead, this research project evaluates the ability of reconditioning to counteract or compensate for mortality due to dams, habitat alteration, and anthropogenic changes in environmental conditions that have depressed the expression of and production from iteroparity.

- *expected project benefits (e.g., gene conservation, preservation of biological diversity, fishery enhancement and/or new information);*

Expected project benefits may include:

1) Increased natural production of wild Columbia Basin steelhead populations;
2) Increases in demographic vigor (increased N, *Ne* and *Nb*);
3) Increases in within- and among-population genetic diversity and variability;
4) Reduced population extinction threats,
5) Valuable insight from project data regarding ecological, biological, and physiological processes relevant to successful expression of iteroparity in wild populations of steelhead in the Columbia Basin.

For a more comprehensive treatment of project benefits, refer to the Kelt Project Scoping Document (attached), Section II, 2, Benefit/Risk Analysis, regarding demographic, genetic, and ecological benefits of this project (Subsections a-c respectively).

- *alternatives for resolving the resource problem;*

It is possible that additional methods could effectively restore and/or enhance natural iteroparity among wild Columbia basin steelhead populations. One such alternative could be simply bypassing emigrating steelhead kelts around the Columbia River hydrosystem. This option is being simultaneously evaluated along with kelt reconditioning to empirically address this question, which will be definitively answered following the next three years of coordinated research on both topics. We welcome additional information or recommendations from the ISRP regarding improvement of our proposed methods to enhance iteroparity, as well as information concerning alternative methods.

- *rationale for the proposed project;*

Populations of wild steelhead *(O. mykiss)* have declined dramatically from historical levels in the Columbia and Snake rivers (Nehlsen et al. 1991; NRC 1996; *US v. Oregon* 1997; ISRP 1999). Steelhead in the upper Columbia River have been listed as endangered under the Endangered Species Act (ESA) since 1997[7]. Those in the Snake River have been listed as threatened, also since 1997[1], and those in the mid-Columbia were listed as threatened in 1999[8]. Causes of the declines are numerous and well known (TRP 1995; NPPC 1986; NRC 1996; ISRP 1999), and regional plans recognize the need to protect and enhance weak upriver steelhead populations while maintaining the genetic integrity of those stocks (NPPC 1995).

Iteroparity rates for *0. mykiss* were estimated to be as high as 79% for 1994-96 in the Utkholok River of Kamchatka (MSU undated; M. Powell UI and R. Williams, ISRP pers. comm.) Reported iteroparity rates for Columbia basin steelhead (*O. mykiss*) were considerably lower, due largely to high mortality of downstream migrating kelts at hydropower dams (Evans and Beaty 2001; Evans In Review), and to inherent differences in iteroparity rate based on geography (e.g. latitudinal effect, inland distance effect; Withler 1966; Bell 1980; Fleming 1998). Chilcote (In Review) reported iteroparity rates ranging from 3 to 21% for 12 different steelhead populations in Oregon. Outmigrating steelhead averaged 58% of the upstream run in the Clackamas river from 1956 to 1964 (Gunsolus and Eicher 1970). Recent estimates of repeat spawners in the Kalama River (tributary of the unimpounded lower Columbia River) have exceeded 17% (NMFS 1996), which is the highest published iteroparity rate we found from the Columbia River Basin. Farther upstream, 4.6% of the summer run in the Hood River (above only one mainstem dam) are repeat spawners (J. Newton, ODFW, pers. comm.). Iteroparity for Klickitat River steelhead was reported at 3.3% from 1979 to 1981 (Howell et al. 1984). Summer steelhead in the South Fork Walla Walla River exhibited estimated 2% to 9% iteroparity rates (J. Gourmand, ODFW, pers. comm.), whereas repeat spawners composed only 1.6% of the Yakima River wild run (from data in Hockersmith et al. 1995) and 1.5% of the Columbia River run upstream from Priest Rapids Dam (L. Brown, WDFW, unpubl. data).

Before repeat spawners can contribute to population growth and diversity, they must first successfully emigrate to the ocean following spawning. Thus, the reconditioning program may provide a needed mechanism for kelts to survive, re-mature, and exhibit iteroparity, or multiple spawnings. Benefits of expressed iteroparity may include: 1) increased natural production of wild Columbia Basin steelhead populations; 2) increases in demographic vigor (increased N, *Ne* and *Nb*); 3) increases in within- and among-population genetic diversity and variability; 4) reduced population extinction threats; and 5) valuable insight from data regarding ecological, biological, and physiological processes relevant to successful expression of iteroparity in wild populations of steelhead in the Columbia Basin. Additional rationale is that kelt reconditioning may provide the above benefits, with relatively little intervention, and thus minimize negative effects of more intrusive or disruptive intervention.

For a more comprehensive treatment of project benefits, refer to the Kelt Project Scoping Document (attached), Section II, 2, Benefit/Risk Analysis, regarding demographic, genetic, and ecological benefits of this project (Subsections a-c respectively).

- *how the proposed production project will maintain or sustain increases in production;*

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[7] Final Rule 8/18/97: 62 FR 43937-43954.
[8] Final Rule 3/25/99: 64 FR 14517-14528.

Reconditioning may maintain or sustain increases in natural production by compensating for mortality of emigrating kelts due to the Columbia River hydropower system. During low or no-spill years (e.g. 2001), the in-river mortality rate for emigrating kelts was estimated at > 96%, based on radio telemetry data from 202 kelts tagged at Lower Granite Dam and tracked to below Bonneville Dam (Allen Evans, CRITFC personal communication). Although this mortality rate may decrease during spill-years, the ability to reduce or eliminate dam-caused mortality may provide substantial benefits in the form of maintained or sustained increases in natural production.

This project is designed to increase production by enabling kelts to survive and successfully exhibit iteroparity (successfully spawn more than once). Re-establishment, enhancement, and maintenance of iteroparity (by reconditioning and /or bypass) is the proposed mechanism for maintained or sustained increases in natural production of steelhead in the Columbia River Basin.

- *the historical and current status of anadromous and resident fish in the subbasin;*

This project is system-wide and therefore is not associated with any single subbasin. Our past experiments have been conducted on the Yakima River. As proposed in the System wide Province Review, the project would operate in the Yakima, Umatilla, Imnaha, and Grande Ronde subbasins (See Table 1, next page).

Table 1. Historical and current escapement estimates where available, and current status of salmon and steelhead in the Yakima, Umatilla, Imnaha, and Grand Ronde subbasins.

		Chinook					
		Spring	**Spring / Summer**	**Fall**	**Steelhead**	**Sockeye**	**Coho**
Subbasin	**Yakima**	**Historically: 50K to 200K Currently: mean escapement 3,591**		**Historically: 38K to 100K Currently: mean escapement 3,159**	**Historically: 28.5K to 100K Currently: mean escapement 1,256 ESA Listed Threatened**	**Historically: 211K Currently: extirpated A few returns from experimental releases of Wenatchee Stock.**	**Historically: 44K to 150K Currently: extirpated but hatchery released fish are naturally reproducing**
	Umatilla	**Historically: 75K Currently: Extirpated About 3K escapement from supplementation program**			**Historically: Unknown Currently: Mean escapement 2,500**		**Historically: Unknown Currently: Extirpated, reintroduced with escapement of 356 to 3000**
	Imnaha		**Historically: Estimated escapement of 6,700 before lower Snake dams. Currently: ESA Listed; Threatened**	**Historically: Unknown Currently: ESA Listed; Threatened**	**Historically: Estimated escapement of 4,000 in the 1960's Currently: ESA Listed; Threatened**		**Historically: Unknown Currently: Extirpated**
	Grande Ronde	**Historically: Escapement of 12,200 in 1957. Currently: ESA Listed; Threatened**		**Historically: Unknown Currently: ESA Listed; Threatened Mean redd count about 30.**	**Historically: Escapement of 15,900 in 1957. Currently: ESA Listed; Threatened**		**Historically: Unknown Currently: Extirpated**

- *the current (and planned) management of anadromous and resident fish in the subbasin;*

- *consistency of proposed project with Council policies, National Marine Fisheries Service recovery plans, other fishery management plans, watershed plans and activities;*

The current and planned management of anadromous and resident fish in the subbasins where this project is proposed (Yakima, Umatilla, Imnaha, and Grande Ronde) are well described in the subbasin summaries that were recently drafted as part of the Rolling Provincial Review Process. These management plans include input from multiple government levels: Federal, Tribal, State, County, Water District, Towns; and multiple departments within government levels. These plans are well described and can be located at links provided in the following table.

Subbasin	Link	Page Number
Yakima	http://www.cbfwa.org/files/province/plateau/PlateauAWP/010803YakimaSec1_2Draft.doc	280
Umatilla	http://www.cbfwa.org/files/province/plateau/PlateauAWP/010803UmatillaDraft.doc	134
Imnaha	http://www.cbfwa.org/files/province/blue/subsum/010601Imnaha.doc	105
Grande Ronde	http://www.cbfwa.org/files/province/blue/subsum/010601Grande.doc	101

- *potential impact of other recovery activities on project outcome;*

Potential impacts of other recovery activities on the outcome of the kelt reconditioning project appear favorable, especially those involving increased spawning and rearing habitat quantity and quality. Habitat improvement projects can contribute to the magnitude of increased natural production in systems which stand to benefit from increasing run sizes due to reconditioning and bypass experiments (BPA 2000-17). Furthermore, projects which increase run sizes resulting from supplementation projects, provide opportunities for natural selection to operate on a more diverse assemblage of spawners and pre-spawners, theoretically producing a more vigorous run through competition. For further detail, see the Kelt Project's Mainstem/Systemwide proposal, Part 2, Section 9, d. "Relationship to Other Programs") at http://www.cbfwf.org/files/province/systemwide/projects/200001700.htm).

- *production objectives, methods and strategies;*

Because kelt reconditioning is a research project to evaluate various treatments on reestablishment and enhancement of iteroparity, production objectives are dictated by adequate sampling requirements to test treatment effects, and by availability of wild kelts in each study stream or basin. For example, groups of $\leq$ 200 kelts will be targeted for short-term reconditioning with the surviving proportion trucked and released downstream from Bonneville Dam. (Survival of short-term reconditioning groups at Prosser Hatchery ranged from 81 to 86% during 2002). Reconditioning methods and strategies are described in detail in the mainstem/Systemwide proposal (http://www.cbfwf.org/files/province/systemwide/projects/200001700.htm), Part 2, Section 9, f. "Proposal objectives, tasks and methods"), and in the methods section of the 2002 Project Statement of Work, Section 2, "Technical Tasks".

- *brood stock selection and acquisition strategies;*

Proposed reconditioning sites were chosen to address reestablishment and/or enhancement of iteroparity in imperiled wild steelhead populations. Kelt selection and acquisition strategies are detailed in the Kelt Project's accompanying 2002 Scope of Work and Mainstem/Systemwide proposal (Part 2, Section 9, f, Task 1.2) (http://www.cbfwf.org/files/province/systemwide/projects/200001700.htm). No broodstock are selected *per se* because this experimental research project relies on natural production of iteroparous kelts in natal streams after reconditioning. Where possible, all emigrating kelts will be sampled and when in appropriate physiological condition, can be incorporated into the reconditioning program.

- *rationale for the number and life-history stage of the fish to be stocked, particularly as they relate to the carrying capacity of the target stream and potential impact on other species;*

All fish released from the kelt reconditioning program (BPA 2000-17) will be wild, reconditioned kelts, and wild non-reconditioned kelts to serve as experimental subjects of bypass experiments, in which kelts are experimentally bypassed by truck or barge around the Columbia River hydro system. Numbers of fish depend on numbers of kelts available for reconditioning from each experimental wild population. Currently, the magnitude and effects of returning repeat spawners is unknown, but the program offers potentially beneficial outcomes, demographically and genetically (See accompanying Scoping Document, Section II, 2, a-c for more details).

In terms of carrying capacity, the reconditioning program is not expected to increase spawner numbers above historical levels. Therefore, the issue of increasing numbers of spawning steelhead above carrying capacity by reconditioning and/or bypass involves artificial reductions in carry capacity (e.g. habitat loss, degradation, and mortality in passage corridor). Data on these potential effects will be collected and analyzed if the project's Mainstem/Systemwide proposal is approved and implemented.

- *production profiles and release strategies;*

Because kelt reconditioning is strictly a research project, specific production profiles, such as those included in supplementation program's Master Plans are not applicable. In this project, artificial production is replaced by increased post-spawning survival through reconditioning and/or bypass, whereby subsequent production occurs through natural spawning in natal streams by reconditioned, repeat spawners.

Kelt release strategies include:

1) Short-term reconditioning (8 weeks) and transport to unimpounded Columbia River release site downstream from Bonneville Dam;

2) Long-term reconditioning (~ 6-8 months) and release in forebay of adjacent downstream mainstem dam, in synchrony with migrating pre-spawning wild cohorts in the mainstem. For example, wild Yakima River steelhead undergoing long-term reconditioning at the Prosser Hatchery will be released in the McNary Dam forebay when a peak of the wild run is passing McNary on its way to naturally spawn in the Yakima River).

3) Bypassed fish (e.g. wild Yakima River population) will be collected at Prosser, subjected to standard in-processing, then bypassed by truck to the standard release site in the unimpounded lower Columbia River downstream from Bonneville Dam (See accompanying Mainstem/Systemwide proposal, Part 2, Section 9, f, Task 1.2 at

http://www.cbfwf.org/files/province/systemwide/projects/200001700.htm) for details of release strategies).

- *production policies and procedures;*

Because kelt reconditioning is strictly a research project, many production policies emerging from Basin-wide APR processes are not applicable to this project. In terms of production policies, kelt reconditioning involves only wild steelhead, whose ability to increase natural production by circumventing anthropogenic limitations is being evaluated. If reconditioning is referred to as production, accompanying production procedures are presented in detail in the project's 2002 Statement of Work, Section 2, "Technical Tasks", and in the project's Mainstem/Systemwide proposal, Part 2, Section 9, f, "Proposal objectives, tasks, and methods".

- *production management structure and process;*

Because this kelt reconditioning is strictly a research project, many production management issues emerging from Basin-wide APR processes are not applicable to this project.

- *related harvest plans;*

Harvest management for these stocks falls under the umbrella of the U.S. v Oregon decision (US *v.* OR 1997).

- *constraints and uncertainties, including genetic and ecological risk assessments and cumulative impacts;*

Constraints and uncertainties, including genetic and ecological risk assessments and cumulative impacts are specifically addressed in the accompanying Scoping Document. In that document, Section II, 2, "Kelt reconditioning benefit/risk analysis addresses demographic, genetic, ecological and pathological benefits and risks associated with this project (Sections II, 2, a-d respectively), and Section II, 4, "Critical uncertainties and pertinent kelt reconditioning research questions, (Subsections a-f) address these issues in detail.

- *monitoring and evaluation plans, including a genetics monitoring program;*

Steelhead kelt reconditioning is strictly a research project. Therefore, evaluations are performed using specific experimental designs that are detailed in the attached statement of work.

- conceptual design of the proposed production and monitoring facilities, including an assessment of the availability and utility of existing facilities; and

Because the kelt project is strictly a research project, no decisions or recommendations are yet available regarding its implementation. Therefore, this question is not applicable to the kelt reconditioning program (BPA 2000-17) at time this. However, all kelt reconditioning research, to date and proposed, maximizes benefits and cost-effectiveness by mutually beneficial, collaborative use of existing facilities and pertinent related research projects.

- cost estimates for various components, such as fish culture, facility design and construction, monitoring and evaluation, and operation and maintenance.

Because the kelt reconditioning program is not a production hatchery, costs of Master Plan components have not been prepared. However, facilities and the breakdown of costs associated with various research tasks are provided in the project's 2002 Statement of Work and the project's Mainstem/Systemwide proposal in Part 1, Sections 5 and 8 (http://www.cbfwf.org/files/province/systemwide/projects/200001700.htm).

The proposed budget for expanded kelt reconditioning and bypass research at four or five locations within the Columbia Basin is approximately $633,000 for FY 2003. However, due to complex logistics of establishing new reconditioning sites on a basin-wide scale for a three-year period, and associated evaluation of objectives and tasks, budget figures may require subsequent modification. Major research scope expansion (> 3 times the project for double the cost), additional objectives and tasks three or four more reconditioning sites, application of initial research to system-wide scale, increased number and scope of objectives, tasks, sites, partners and potential benefits to wild steelhead populations basin-wide are all reasons for project expansion, and associated increases in cost. Unanticipated success in early years of project, unexpectedly large potential benefits, expanded scope and geographic scale to system-wide, and expanded potential benefits to wild steelhead stocks in Basin are factored into the total project cost.

NOTE: Additional project information regarding objectives, tasks, project progress to date, rationale and justification can be found in the project's mainstem/systemwide proposal (http://www.cbfwf.org/files/province/systemwide/projects/200001700.htm) submitted to BPA on June 3, 2002, and in the project's 2002 Statement of Work, and 5-Year Plan (attached).

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Attachment II: <u>Questions Identified in the September 1997 Council Policy Document for FY98 Project Funding</u>

Has the project been the subject of appropriate independent scientific review in the past? If so, how has the project responded to the results of independent review?

Yes, the kelt reconditioning project has experienced past independent scientific review. Past review produced ISRP comments that were addressed in writing and submitted to the Council nad BPA during 2000. This review also resulted in the recommendations to pursue kelt reconditioning research, this partial 3-step review document, the accompanying scoping document, and additional relevant documents (attached) now provided to the Council and BPA.

Have project sponsors demonstrated adequately at earlier stages that the project is consistent with the Council's policies on artificial/natural production in Section 7 (the specific concern of the Panel)? If not, can these points be demonstrated now?

Yes, resulting in the Council's approval of this project on October 10, 2000, with the added condition of providing additional input provided in this package to the Council and BPA.

Is the final design of the project consistent with any master plan and preliminary design?

This question is not directly applicable to the kelt reconditioning project at this time because this project is currently proposed as a set of empirical experiments to evaluate kelt reconditioning as one possible means to restore and enhance natural iteroparity in wild Columbia Basin steelhead popualtions. However, pending the outcome of this research (http://www.cbfwf.org/files/province/systemwide/projects/200001700.htm), final design of any resulting implementation phase kelt reconditioning work will be consistent with appropriate preliminary and master plan designs.

If not, do the changes raise any underlying scientific questions for further review? NA.

Has information about the project or its purposes changed in such a way to raise new scientific concerns?

Yes, kelt reconditioning may provide greater benefit that initially envisioned. Empirical data and information generated by the kelt reconditioning project to date have only further supported positive expectations of kelt reconditioning as a potential future management option for restoring and enhancing natural iteroparity among wild Columbia basin steelhead populations.

Has the underlying science or the way it is understood changed so as to raise new scientific issues?

No, empirical data and information generated by the kelt reconditioning project to date have served to further support positive expectations of kelt reconditioning as a potential future management option for restoring and enhancing natural iteroparity among wild Columbia basin steelhead populations. A more definitive answer to this question will result from the next 3 years of empirical evaluation of kelt reconditioning (http://www.cbfwf.org/files/province/systemwide/projects/200001700.htm).

How technically appropriate are the monitoring and evaluation elements of the project?

Monitoring and evaluation elements of the steelhead kelt reconditioning program are very appropriate. Their appropriateness has direct bearing on objective evaluation of kelt reconditioning, therefore their appropriateness is of utmost importance. This understanding was the main driver in the design of the program's M&E elements.

Are there ways to obtain the same production benefits with facilities that are lower in cost or less permanent, should monitoring and evaluation later indicate that the effort be abandoned?

Yes, it is possible that additional methods could effectively restore and/or enhance natural iteroparity among wild Columbia basin steelhead populations. One such alternative could be simply bypassing emigrating steelhead kelts around the Columbia River hydrosystem. This option is being simultaneously evaluated along with kelt reconditioning to empirically address this question, which will be definitively answered following the next three years of coordinated research on both topics.

Attachment III: **Program Language Identified by the ISRP**

Note: although these NPPC program measures may be outdated relative to this partial 3-step review of steelhead kelt reconditioning, we chose to address them as a further way to convey the relevance and consistency of this program to the Council and BPA.

Measure 7.0D: Comprehensive environmental analysis assessing the impacts on naturally produced salmon of hatchery produced anadromous fish.

Measure 7.0D of the Council's 1994 Fish and Wildlife Program calls for a comprehensive environmental analysis assessing the impacts on naturally produced salmon of hatchery produced anadromous fish. The primary question we would like to have addressed with regard to the project is, does the environmental assessment adequately deal with the question of interactions of hatchery-produced salmonids and naturally spawning salmonids and steelhead in the Columbia River Basin? If so, how? If not, what are the potential or posited interactions and impacts?

This question does not apply to the kelt reconditioning program because it deals exclusively with wild steelhead from Columbia River basin populations.

Measure 7.1A: Evaluation of carrying capacity and limiting factors that influence salmon survival.

Measure 7.1A of the Council's 1994 Fish and Wildlife Program calls for a basin-wide study on the ecology, carrying capacity, and limiting factors that influence salmon survival. The primary question we would like to have addressed with regard to this measure is how does the project intend to address the issue of carrying capacity within the watershed(s) into which fish will be placed?

Carrying capacity will be addressed through evaluation of empirical run size data incorporating repeat spawners generated by this project.

Do these fish originate from the most appropriate native stock?

Yes, the kelt reconditioning project exclusively involves wild fish, using only appropriate wild stocks or populations within their natal streams and river basins for reconditioning research.

Specifically, how will the artificial production which is proposed, impact natural production?

Kelt reconditioning is not viewed as artificial production *per se* , but rather as the enhancement of an evolutionarily advantageous life history strategy, the expression of which has been moderately to severely curtailed by development of the Columbia River hydrosystem. Therefore, impacts on natural production are expected to be and initially appear postitive, providing benefits to population demographics and population genetic characteristics. (See attached Scoping Document (kelt scoping.doc), Section II Kelt Reconditioning Benefit/Risk Analysis for more details).

What are the impacts on mainstem and ocean harvest? How are these impacts addressed?

Because this program works only with wild fish, increased natural production of wild fish is the designed benefit. Therefore, this program is affected by the relationship between increased natural production of wild fish and by-catch. Thus, evaluation of such impacts would have to involve catch data from regulatory agencies and Tribes (e.g. NMFS, CRITFC, state agencies).

Measure 7.1C: Collection of population status, life history and other data on wild and naturally spawning populations of salmon and steelhead.

Measure 7.1C calls for the collection of population status, life history and other data on wild and naturally spawning populations of salmon and steelhead. The primary question we would like to have addressed with regard to this measure, especially with regard to listed species is, what biological baseline information on naturally spawning populations of salmon and steelhead have been collected, and what high priority populations and "provisional population units" have been identified? Does this baseline information include a profile on the genetic and morphological characteristics of wild and naturally spawning populations? What characteristics are to be maintained by management actions? What are the limiting factors for wild and naturally spawning populations? What is the natural carrying capacity for the identified populations? What monitoring of identified populations of salmon and steelhead is identified as part of the project? Are these efforts being coordinated with NMFS? If so, how?

These issues will be more relevant to the kelt reconditioning program and addressed completely if and when experimental kelt reconditioning research adequately concludes that empirical success of such techniques justifies implementation. At this time, the next three years of the reconditioning project are expected to provide definitive recommendations relative to implementation of reconditioning and/or kelt bypass around the Columbia Basin hydropower system, as potential means to restore and enhance expression of natural iteroparity in wild Basin steelhead populations (http://www.cbfwf.org/files/province/systemwide/projects/200001700.htm).

Measure 7.1F: Systemwide and cumulative impacts of existing and proposed artificial production projects on the ecology, genetics and other important characteristics of the Columbia River Basin anadromous and resident fish.

Measure 7.1F calls for a study to address the system wide and cumulative impacts of existing and proposed artificial production activities on the ecology, genetics and other important characteristics of Columbia River Basin anadromous and resident fish. This study is to be coordinated with the genetic impact assessment of Columbia River Basin hatcheries called for in measure 7.2A.2 of the Council's program. How does the projects environmental assessment address the direct, indirect and cumulative effects of the proposed production activities on anadromous and resident fish? Have those effects commonly associated with cumulative hatchery releases -- density dependent, competition, predation, disease transmission and genetic *effects on other fish in the mainstem and oceanic environments been addressed? If so how? Have the genetic effects of the project on fish within and outside the Columbia River Basin been specifically addressed?*

Answers to these questions and discussion of relevant issues are provided in the accompanying scoping document (kelt scoping.doc).

Attachment IV: Fiscal Questions Relating to the Step 3 Review

What are the final cost estimates for Fiscal Year 1999 through 2008 for construction, operation and maintenance, and monitoring and evaluation for the project?

Best estimates and justifications for final costs are provided in the project's Mainstem/Systemwide proposal (http://www.cbfwf.org/files/province/systemwide/projects/200001700.htm). However, at this time such figures simply reflect research, not implementation costs.

Are these cost estimates different form preliminary design estimates?

Yes.

If so, please explain.

Major research scope expansion (> 3 times the program for approximately double the cost), additional objectives, tasks; three more reconditioning sites/populations, application of initial research to system-wide scale; increase in number and scope of objectives and tasks, sites, partners and potential benefits to wild steelhead population in the Basin explain increased costs. These expansions were the logical result of successes beyond expectation during the first two years of kelt reconditioning (Project 2000-17)

Has a value engineering review been performed by BPA to ensure that cost-effective alternate measures are not overlooked? What are the results of the review?

No, BPA has not performed a value engineering review.

Attachment V: <u>Policies of the Artificial Production Review, Report and Recommendations (Document 99-15)</u>

1. *The manner of use and the value of artificial production must be considered in the context of the environment in which it will be used.*

We support the intent and the ecological foundation of this APR Policy. Brannon (1993) reported that " If we neglect the requirements that populations have, and hence the traits that they possess that allow them to synchronize their life history with specific environmental constraints, failure [of hatchery programs] is certain". The design of the steelhead kelt reconditioning program (BPA 2000-17) focuses on synchrony with the local environmental template by: 1) incorporating only wild fish which are products of natural selection in local environments; 2) minimizing the amount of artificial intervention required to restore and/or reestablish natural expression of iteroparity; and 3) not engaging in artificial production *per se*, but enhancing the expression of a natural reproductive strategy (iteroparity) and allowing selection to operate on all life stages following release from reconditioning and/or bypass.

2. *Artificial production must be implemented within an experimental, adaptive management design that includes an aggressive program to evaluate benefits and address scientific uncertainties.*

We are acutely aware of the adaptive management paradigm (Walter 1986; Walters 1997; Walters et al. 2000), and are supportive of its integration into the APR process. Accordingly, this research project provides a good example of initial stages of adaptive management as applied to enhancement of iteroparity in wild steelhead populations. The baseline condition involves currently low empirical values of expressed iteroparity in the post-development Columbia Basin. Experimental treatments include combinations of short- and long-term reconditioning and bypass (Reconditioning methods and strategies are described in detail in the mainstem/Systemwide proposal (http://www.cbfwf.org/files/province/systemwide/projects/200001700.htm), Part 2, Section 9, f. "Proposal objectives, tasks and methods", and in the methods section of the 2002 Project Statement of Work, Section 2 "Technical Tasks").

This project's purpose is to provide a rigorous evaluation of these options for enhancing iteroparity. Thus, project design includes an aggressive evaluation component. Risk management is satisfactorily addressed and maintained in the kelt reconditioning program by: 1) appropriate evaluation strategies in the project's experimental design; 2) genetic, demographic, ecological and pathological benefit/risk analyses in the attached Scoping Document (Section II, 2, a-d); and 3) the same document's responses involving critical uncertainties and answers to pertinent reconditioning research questions (Section II, 4, a-f).

3. Hatcheries must be operated in a manner that recognizes that they exist within ecological systems whose behavior is constrained by larger-scale basin, regional and global factors.

Experimental design of this project is based on the understanding of this APR Policy. The design of the steelhead kelt reconditioning program (BPA 2000-17) focuses on synchrony with the local environmental template by: 1) incorporating only wild fish which are products of natural selection in local environments; 2) minimizing the amount of artificial intervention required to restore and/or reestablish natural expression of iteroparity; 3) not engaging in artificial production per se, but enhancing the expression of a natural reproductive strategy (iteroparity) and allowing selection to operate on all life stages following release from reconditioning and/or bypass. These project design attributes do not isolate reconditioned and bypassed fish from these basin, regional, and global scale ecological factors. Rather, it incorporates effects of their selective pressures, and minimizes artificial selection to a greater degree than possible in most intensive artificial propagation programs.

4. A diversity of life history types and species needs to be maintained in order to sustain a system of populations in the face of environmental variation.

Steelhead in the Columbia River Basin currently exhibit resident and anadromous life history forms, with anadromous forms exhibiting semelparous and iteroparous reproductive strategies. The goal of the steelhead kelt reconditioning program is to maintain and potentially enhance diversity of life history types expressed by wild steelhead in the Basin by restoring and enhancing one of these important and evolutionarily stable forms, iteroparity.

5. Naturally selected populations should provide the model for successful artificially reared populations, in regard to population structure, mating protocol, behavior, growth, morphology, nutrient cycling, and other biological characteristics.

This APR Policy is directly supported by the kelt reconditioning project (BPA 2000-17) because the project involves only wild populations, which represent products of this natural selection model. Furthermore, the kelt reconditioning project does not rear populations per se*, other than to reinitiate feeding and allow somatic and gonadal reconditioning during periods when kelts are being reconditioned in captivity. Therefore, its products (surviving kelts) conform to this model in terms of population structure, mating protocol, behavior etc.. because fish performance relative to these parameters occurs in the wild without intervention, following their release from the program.*

6. *The entities authorizing or managing a artificial production facility or program should explicitly identify whether the artificial propagation product is intended for the purpose of augmentation, mitigation, restoration, preservation, research, or some combination of those purposes for each population of fish addressed.*

For the next three years kelt reconditioning and bypass is strictly a research project to evaluate and rank short- and long-term reconditioning and bypass based on their abilities to restore and enhance steelhead iteroparity (multiple spawnings) in the wild. Upon completion of this 3-year experiment, conclusive recommendations generated by this project will be provided to managers and scientific reviewers to assist in determining which methods could be best implemented to restore iteroparity in wild steelhead populations. At that time reconditioning and/or bypass may be considered, approved and adopted for implementation for the purposes of augmentation, mitigation, restoration, preservation, or some combination.

7. *Decisions on the use of the artificial production tool need to be made in the context of deciding on fish and wildlife goals, objectives and strategies at the subbasin and province levels.*

Kelt reconditioning is included in the Artificial Production Program Summary (http://www.cbfwa.org/files/province/systemwide/subsum/020222ArtProd.doc) that is a part of the System-wide Province Review. Kelt reconditioning research is called for in the Biological Opinion e.g. "***Action 109:*** The Corps shall initiate an adult steelhead downstream migrant (kelt) assessment program to determine the magnitude of passage, the contribution to population diversity and growth, and potential actions to provide safe passage…. Evaluation should be conducted to review available literature and develop pilot testing regarding reconditioning of kelts", and by 8 NMFS RPA's (See Kelt reconditioning Mainstem/Systemwide proposal, Part 1, Section 1 at: (http://www.cbfwf.org/files/province/systemwide/projects/200001700.htm).

8. *Appropriate risk management needs to be maintained in using the tool of artificial propagation.*

Risk management is satisfactorily addressed and maintained in the kelt reconditioning program by: 1) appropriate evaluation strategies in the project's experimental design; 2) genetic, demographic, ecological and pathological benefit/risk analyses in the attached Scoping Document (Section II, 2, a-d); and 3) the same document's responses involving critical uncertainties and answers to pertinent reconditioning research questions (Section II, 4, a-f).

9. *Production for harvest is a legitimate management objective of artificial production, but to minimize adverse impacts on natural populations associated with harvest management of artificially produced populations, harvest rates and practices must be dictated by the requirements to sustain naturally spawning populations.*

This APR Policy does not apply to the kelt reconditioning project (BPA 2000-17) at this time because the project does not involve production for harvest.

10. *Federal and other legal mandates and obligations for fish protection, mitigation, and enhancement must be fully addressed.*

All research, monitoring, and evaluation components of the kelt reconditioning project are met and are consistent with all legal mandates at this time. Future NEPA work and other related tasks to maintain compliance are planned and presented as a separate objective in the project's Mainstem/Systemwide proposal for ongoing research (http://www.cbfwf.org/files/province/systemwide/projects/200001700.htm).

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